



**University of Illinois Urbana-Champaign
High Temperature Gas-cooled
Research Reactor:
Applicability of
Nuclear Regulatory Commission Regulations**

TOPICAL REPORT

**Issued by
Ultra Safe Nuclear Corporation
to
The University of Illinois Urbana-Champaign
under
USNRC Project No. 99902094**

March 15, 2024

Approved: July 25, 2024



**UNITED STATES
NUCLEAR REGULATORY COMMISSION**
WASHINGTON, D.C. 20555-0001

July 25, 2024

Dr. Caleb S. Brooks, Associate Professor
Department of Nuclear, Plasma,
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**SUBJECT: UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN – SAFETY EVALUATION
FOR TOPICAL REPORT TITLED “HIGH-TEMPERATURE GAS-COOLED
RESEARCH REACTOR: APPLICABILITY OF NUCLEAR REGULATORY
COMMISSION REGULATIONS,” RELEASE 4 (EPID L-2022-NFN-0008)**

Dear Dr. Brooks:

By letter dated December 9, 2022 (Agencywide Documents Access and Management System Accession No. ML22343A282), the University of Illinois at Urbana-Champaign (UIUC) submitted the topical report (TR) “University of Illinois Urbana-Champaign High Temperature Gas-cooled Research Reactor: Applicability of Nuclear Regulatory Commission Regulations,” Release 1, for U.S. Nuclear Regulatory Commission (NRC) staff review. Following several interactions with the NRC staff, UIUC submitted Release 4 of the TR by letter dated March 15, 2024 (ML24075A304).

The NRC staff’s safety evaluation (SE) for the TR, Release 4, is enclosed. The enclosed SE will be made publicly available.

The enclosed SE finds that Release 4 of the TR identified a generally acceptable list of applicable regulatory requirements for use in developing a license application for the described UIUC Micro Modular Reactor research reactor, subject to the limitations and conditions listed in the enclosed SE.

The NRC staff requests that UIUC publish an accepted version of this TR within 3 months of receipt of this letter. The accepted version should incorporate this letter and the enclosed SE after the title page. The accepted version should include an “-A” (designating “accepted”) following the TR identifier.

If you have any questions, please contact Paulette Torres at (301) 415-5656, or by email at Paulette.Torres@nrc.gov.

Sincerely,

A handwritten signature in black ink, appearing to read "Holly D. Cruz".

Signed by Cruz, Holly
on 07/25/24

Holly D. Cruz, Acting Chief
Non-Power Production and Utilization Facility
Licensing Branch
Division of Advanced Reactors and Non-Power
Production and Utilization Facilities
Office of Nuclear Reactor Regulation

Project No.: 99902094

Enclosure:
As stated

cc: GovDelivery Subscribers

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ADAMS Accession Number: ML24165A000**NRR-106**

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**UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN – SAFETY EVALUATION FOR
TOPICAL REPORT TITLED “HIGH-TEMPERATURE GAS-COOLED RESEARCH REACTOR:
APPLICABILITY OF NUCLEAR REGULATORY COMMISSION REGULATIONS,” RELEASE 4
(EPID L-2022-NFN-0008)**

APPLICANT INFORMATION

Applicant: University of Illinois at Urbana-Champaign

Applicant Address: 104 South Wright St.
Urbana, IL 61801

Docket/Project No(s): 99902094

APPLICATION INFORMATION

Submittal Date: December 9, 2022

Submittal Agencywide Documents Access and Management System (ADAMS) Accession No.: ML22343A282 - University of Illinois at Urbana-Champaign (UIUC, the applicant) Applicability of U.S. Nuclear Regulatory Commission (NRC) Regulations Topical Report (TR), Release 1

Supplement ADAMS Accession No(s):

- ML23242A329 - UIUC, Submittal of Revised UIUC Applicability of NRC Regulations TR, Release 2, dated August 30, 2023
- ML23345A236 - UIUC, Response to NRC Request for Additional Information regarding UIUC Applicability of NRC Regulations TR, Release 2, dated December 11, 2023
- ML24060A265 - UIUC, Submittal of Revised UIUC Applicability of NRC Regulations TR, Release 3, dated February 29, 2024
- ML24075A304 - UIUC, Submittal of Revised UIUC Applicability of NRC Regulations TR, Release 4, dated March 15, 2024

Other Communication ADAMS Accession No(s):

- ML23159A036 - USNRC, Public Meeting Notice Regarding the NRC Staff's Review of UIUC Applicability of NRC Regulations TR, dated May 24, 2023
- ML23151A544 - USNRC, Proposed Discussion Topics regarding NRC Staff's Review of UIUC Applicability of NRC Regulations TR, dated May 31, 2023
- ML23158A252 - UIUC, Presentation Addressing Proposed Discussion Topics, dated June 7, 2023
- ML24031A626 - USNRC, Summary of the January 24, 2024, Public Meeting regarding UIUC Applicability of NRC Regulations TR, dated January 31, 2024

Enclosure

Brief Description of the Topical Report: By letter dated December 9, 2022, UIUC submitted Release 1 of TR, “University of Illinois Urbana-Champaign High Temperature Gas-cooled Research Reactor: Applicability of Nuclear Regulatory Commission Regulations,” for the NRC staff’s review. The TR reflects UIUC’s screening of Title 10, “Energy,” of the *Code of Federal Regulations* (10 CFR), Chapter I, “Nuclear Regulatory Commission,” to determine regulations applicable to a research reactor, including requirements in 10 CFR Part 20, “Standards for Protection Against Radiation”; Part 50, “Domestic Licensing of Production and Utilization Facilities”; Part 51, “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions”; Part 70, “Domestic Licensing of Special Nuclear Material”; Part 73, “Physical Protection of Plants and Materials”; and Part 74, “Material Control and Accounting of Special Nuclear Material.”

The NRC staff arranged a public meeting with UIUC on June 8, 2023, that resulted in UIUC submitting revised TR (Release 2) and a second public meeting with UIUC on January 24, 2024, that resulted in UIUC submitting revised TR (Release 3). After additional clarification discussions, UIUC submitted revised TR (Release 4).

In Release 4 of the TR, UIUC requested NRC review and approval of the TR to determine applicability of specific regulations as part of the licensing requirements for the Ultra Safe Nuclear Corporation’s Micro Modular Reactor (MMR™) high-temperature, gas-cooled reactor (HTGR) design proposed for UIUC. The request was submitted assuming the MMR at UIUC would meet the criteria for licensing as a Class 104c. research reactor in accordance with 10 CFR 50.21(c). In TR Section 1.5, “NRC Action Requested,” UIUC stated that the TR description of the methodology developed and employed for determining the applicability of regulations was provided for informational purposes only; UIUC states that it is only requesting NRC review and approval of the TR “to determine acceptability of specific regulations identified in [the] TR as the licensing basis for the MMR at UIUC, listed in Attachment 1, ‘Assignment of NRC Regulations to UIUC-MMR Regulation Applicability Groups’” of the TR.

For additional details on the submittal, please refer to the documents located at the ADAMS Accession No(s). identified above.

EVALUATION CRITERIA

UIUC is pursuing the licensing of an MMR design as a non-commercial research reactor. The applicant stated that UIUC will be applying for a construction permit (CP) and subsequent operating license (OL) under 10 CFR Part 50 regulations. The applicant also stated an intent to license the research reactor as a Class 104c. facility under 10 CFR 50.21(c).

To facilitate future licensing actions, it is useful to identify the specific regulatory framework applicable to the UIUC MMR during the initial stages of the licensing process. Certain definitions provided in 10 CFR 50.2 are relevant to the applicability of regulations, including the following:

- *Non-power reactor* means a research or test reactor licensed under §§ 50.21(c) or 50.22 of this part for research and development.
- *Testing facility* means a nuclear reactor which is of a type described in § 50.21(c) of this part and for which an application has been filed for a license authorizing operation at:
 - (1) A thermal power level in excess of 10 megawatts; or
 - (2) A thermal power level in excess of 1 megawatt, if the reactor is to contain:
 - (i) A circulating loop through the core in which the applicant proposes to conduct fuel experiments; or

- (ii) A liquid fuel loading; or
- (iii) An experimental facility in the core in excess of 16 square inches in cross-section.

In order to be licensed as a non-commercial (Type 104) research reactor, the provisions of 10 CFR 50.22 require that no more than 50 percent of the annual cost of owning and operating the facility is devoted to the production of materials, products, or energy for sale or commercial distribution, or to the sale of services, other than research and development or education or training.¹

Given that the UIUC intends to submit an application to license the MMR as a research reactor in accordance with 10 CFR 50.21(c), NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content," which was issued in February 1996 (Reference 1), serves as guidance. Appendix A, "Applicability of Selected Regulations in Title 10, Chapter I, of the Code of Federal Regulations to Non-Power Reactors," of NUREG-1537, Part I, informs the applicability to research reactors of NRC regulations existing at the time of NUREG-1537 issuance. However, it may not provide accurate information regarding applicability of regulations modified since that time and does not address regulations added since that time.

NRC regulations include provisions that provide some regulatory flexibility. All Parts of Chapter I of Title 10 within the scope of the TR include provisions for specific exemptions from individual regulations. The requirements of 10 CFR 50.12, "Specific exemptions," state, in part, that the Commission may, upon application by any interested person or upon its own initiative, grant exemptions from the requirements of the NRC regulations in Part 50 when:

- 1) The exemptions are authorized by law, will not present an undue risk to the public health and safety, and are consistent with the common defense and security; and
- 2) Special circumstances are present.

Special circumstances listed in 10 CFR 50.12(a)(2) include:

- (ii) Application of the regulation in the particular circumstances would not serve the underlying purpose of the rule or is not necessary to achieve the underlying purpose of the rule; or
- (iv) The exemption would result in benefit to the public health and safety that compensates for any decrease in safety that may result from the grant of the exemption.

The specific exemption requirements in other Parts of Chapter I of Title 10 generally do not require the presence of special circumstances but are otherwise similar.

¹ The staff acknowledges that section 601, "Technical Correction," of the Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy Act of 2024, also known as the ADVANCE Act, amended section 104c. of the Atomic Energy Act of 1954 (AEA), as amended, to specify that the NRC may issue a license under section 104c. for a utilization facility useful in the conduct of research and development if two conditions are satisfied: (A) not more than 75 percent of the annual costs to the licensee of owning and operating the facility are devoted to the sale, other than for research and development or education and training of (i) non-energy services; (ii) energy; or (iii) a combination of nonenergy services and energy; and (B) not more than 50 percent of the annual costs to the licensee of owning and operating the facility are devoted to the sale of energy. See Pub. L. No. 118-67, div. B, section 601 (to be codified at 42 U.S.C. section 2134(c)). This amendment to AEA section 104a. became effective immediately upon enactment of the ADVANCE Act on July 9, 2024.

The NRC staff issued a draft document, titled “Updated NRC Staff Draft White Paper – Analysis of Applicability of NRC Regulations for Non-Light Water Reactors” (Draft White Paper), dated July 2021 (Reference 2), that provisionally identified NRC regulations in Part 50 and Part 52 that are generically either applicable or inapplicable to licensing of non-light-water power reactors (non-LWRs).² The UIUC TR referenced the general methodology found in the draft white paper, with consideration of the UIUC MMR intended status as a research reactor, to evaluate the applicability of regulations and identify potential exemptions necessary for the MMR research reactor design.

After the submission of Release 4 of the UIUC TR, the NRC staff issued Division of Advanced Reactors and Non-Power Production and Utilization Facilities (DANU) Interim Staff Guidance (ISG) 2022-01, “Review of Risk-Informed, Technology-Inclusive Advanced Reactor Applications—Roadmap,” March 2024 (Reference 3) (Roadmap ISG). Appendix B, “Analysis of Applicability of NRC Regulations to Non-Light-Water Power Reactors,” to DANU-ISG-2022-01 includes an analysis of the applicability of NRC regulations to advanced power reactors. While Appendix B to the Roadmap ISG includes a significant amount of information that remained unchanged from the Draft White Paper, Appendix B also includes corrections to several errors in the Draft White Paper. The NRC staff reviewed the UIUC TR based on the information in Appendix B to the Roadmap ISG (considering that the proposed UIUC MMR would be a research reactor).

A previous review provides a precedent for evaluation of regulatory applicability to a Non-Power Reactor. By letter dated January 18, 2022 (Reference 4), Kairos Power LLC submitted Revision 4 of TR KP-TR-004-NP, “Regulatory Analysis for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor,” which addressed applicability of NRC regulations for both a proposed power reactor and a proposed test reactor. A test reactor is classified as a non-power reactor by the definition of “Non-power reactor” in 10 CFR 50.2, but test reactors are subject to some regulations not applicable to research reactors. The NRC staff accepted Revision 4 of KP-TR-004-NP and determined that, with some exceptions identified in the safety evaluation (SE), the report identified regulations applicable to the proposed Kairos reactors. Kairos forwarded the approved version of KP-TR-004-NP with the associated NRC SE by letter dated June 8, 2022 (Reference 5).

TECHNICAL EVALUATION

To support future licensing actions, UIUC has reviewed the NRC’s regulations to identify requirements prior to submission of a formal license application in order to support a more efficient and timely review. The applicant compared MMR technology to the light-water reactor (LWR) technology that is reflected in many regulations and evaluated the applicability of regulations for licensing of the UIUC MMR.

² The Draft White Paper included the following disclaimer:

The NRC staff has prepared this draft white paper and is releasing it to support an upcoming advanced reactor stakeholder meeting. The U.S. Nuclear Regulatory Commission (NRC) staff intends this draft white paper to facilitate discussion at the meeting but is not soliciting written Comments on it. The contents of this document are subject to change and should not be interpreted as official agency positions. Ultimately, the NRC staff plans to issue guidance on the applicability of current NRC regulations to non-light water reactors and will seek public comments on the guidance document.

1. APPLICABILITY OF REGULATIONS TO NON-LWR TECHNOLOGIES

1.1. MMR Design Features

Section 2.0 of the TR describes key design features that distinguish the MMR design from LWRs. The MMR primary coolant loop uses helium circulated via pumps to cool the reactor. UIUC states that the reactor will be fueled with Tri-Structural Isotropic (TRISO) fuel particles embedded in silicon carbide Fully Ceramic Micro-Encapsulated pellets. UIUC intends to credit the barriers associated with the TRISO fuel as part of a functional containment, as described in SECY-18-0096, "Functional Containment Performance Criteria for Non-Light-Water-Reactors," issued September 28, 2018 (Reference 6). The intermediate coolant loop contains molten salt for transferring heat from the helium to the electrical power generation side of the facility, which UIUC states provides a means to separate the reactor from external transients. While still pressurized, UIUC states that the MMR will have a lower operating pressure and much lower stored energy than an LWR. UIUC also states that safety-related, passive decay heat removal is available without helium, electrical power, or operator action. The applicant summarized features differentiating the MMR from operating LWRs in table 2-1, "MMR Key Features and Differences from Operating LWRs," in Release 4 of the TR.

Section 3.0 of the TR includes a discussion on regulatory foundations for licensing a nuclear reactor. UIUC highlights certain parts of 10 CFR Chapter I and the licensing process, precedent with previous advanced designs licensed by the Atomic Energy Commission, and references examples of regulations not applicable to the MMR design given fundamental design differences relative to LWRs and specific entry conditions indicating applicability to LWRs. The key design features highlighted by UIUC are described to show differentiation from current LWRs and the design focused regulations associated with them. The applicant stated that entry conditions would be used in the determination of regulation applicability with considerations of design differences from LWRs to inform exemptions and applicability of regulations.

1.2. NRC Staff Evaluation

Appendix B to DANU-ISG-2022-01 states that some regulations may be inapplicable to a particular non-LWR design or application because of entry conditions already present in the rule. In these cases, the applicant is expected to document and support its claim that a requirement is inapplicable because of the entry condition. The NRC staff considered section 2.0 of the TR as information only in the context of supporting a determination that entry conditions associated with LWR technology would not apply. The NRC staff makes no evaluation regarding the adequacy of the design.

As part of the review to establish regulatory applicability, the NRC staff evaluated design features that differentiate the MMR design from that of LWRs. The NRC staff concludes that the inclusion of an inert helium coolant and other features summarized in table 2-1 of the TR adequately support a determination that entry conditions that specifically limit the applicability of a regulation to LWRs, including Boiling Water Reactors (BWRs) and Pressurized Water Reactors (PWRs) or systems or components that perform functions unique to those types of designs, would not be applicable to the UIUC MMR design. The staff also notes that the UIUC MMR would also be excluded from these regulations as a research reactor.

2. APPLICABILITY IDENTIFIED IN REGULATIONS VIA ENTRY CONDITIONS

2.1. Determination of Applicability

The applicant noted the differing applicability of NRC regulations based on reactor technology and other factors in section 4.0, “Applicability of Specific Regulations to MMR Technology,” of Release 4 of the TR. The applicant developed a process to categorize regulations with respect to relevance considering the entry conditions or other plain language included in the regulation. In table 4-1 of the TR, UIUC proposed eight different regulatory applicability groups distinguished by the applicability of entry conditions, other plain language direction, or actions expected to be necessary for compliance with the regulations. The applicant defined the Regulation Applicability Groups (RAGs) as follows:

- **1 N/A** – HTGR/MMR technology differs in fundamental ways from that of LWRs. The capability, system, or feature is not required. Regulations in this group are not applicable because they have entry criteria ... pertaining to:
 - Facility type: those that are not a utilization facility (i.e., not a reactor)
 - Reactor type: specifically applicable to a LWR (PWR, BWR) or D₂O [Heavy Water Reactor]
 - Specific time frame: applications submitted prior to 2023
 - Specific license application: those that reference a specific project
 - Application type: other than Part 50 [CP] and [OL]
- **2 N/A to NPUF** [non-power production or utilization facility] – NPUFs do not need to meet regulations that have entry conditions pertaining to a “nuclear power plant,” “power reactor,” or similar. Based upon UIUC qualifying for a Class [104c.] license, which is a [NPUF], the power reactor regulations are not applicable.
- **3 Applicable as is** – Regulation applies, although there may be sub-paragraphs that have their own specific entry conditions as noted.
- **3A Modified/partial** – Regulation applies, with some specific limitations or modifications, which are not considered to be significant deviations that require an exemption, or where portions down to the paragraph level may not be applicable and would be so noted as N/A in the subsequent row(s).
- **3B Meets intent** – Regulation applies and the underlying safety basis is relevant, but the means of implementation are subject to interpretation. The UIUC approach is considered to meet the intent of the regulation and not require an exemption. An alternative approach would be more appropriate for the MMR design to meet the regulation. This will be provided in the [preliminary safety analysis report] and [final safety analysis report].
- **3C Administrative** – Applies but does not affect design or technical requirements.
- **3D NRC, not applicant** – Regulation pertains to NRC activities not relevant to an applicant or licensee.
- **4 Request exemption** – UIUC may deviate from the regulation. UIUC may request an exemption.

Section 4.1 of the TR describes the process of determining “Entry Conditions for Regulation Applicability” given in TR table 4-2. The table lists phrases indicating conditions applicable to the proposed UIUC MMR and conditions not considered applicable to the proposed UIUC MMR that may appear in specific regulations.

Section 4.1 of the TR also references TR table 5.1, “Steps in Process to Evaluate NRC Regulation Applicability to UIUC MMR,” to define a process to determine applicability of individual regulations. The following list summarizes the guidance in TR table 5.1:

- Search regulations to identify terms characterized as “entry conditions” (see TR table 4-2) and determine applicability to the UIUC MMR.
- Compare results of the applicability determination to the following existing assessments of regulatory applicability, and reconcile differences:
 - Kairos TR KP-TR-004-NP, Revision 4, list of applicable regulations and associated NRC SE;
 - Guidance in NRC Draft White Paper;³ and
 - Appendix A to NUREG-1537
- Resolve remaining questions through review of statements of consideration for the associated regulations in the *Federal Register* and other documents developed by the NRC.

In the remainder of section 4.0 of the TR, the applicant described consideration of other information addressing applicability of regulations. The applicant assessed use of the NRC Draft White Paper in determining the applicability of regulations to the UIUC MMR in section 4.2 of the TR. In section 4.3 of the TR, the applicant described the NRC evaluation of the Kairos KP-TR-004-NP and noted that differences from accepted applicability determinations for the Kairos test reactor would derive primarily from technology differences (high temperature gas-cooled reactor vs. molten-salt-cooled reactor) and the difference in power rating (research reactor vs. test reactor). The applicant did not consider a submittal from Oklo Power, LLC, relevant to the UIUC MMR design. The applicant also described consideration of licensing alternatives to define applicable regulations, including future rulemaking, NRC hearing Orders, and Rules of Particular Applicability, but the applicant elected to evaluate the normal licensing process with exemptions.

Section 5.0, “Exemption Process,” of the TR outlines the applicant’s review of regulations to determine whether exemptions would be necessary. This section describes the exemption process and the method to identify applicable regulations and, from those, determine if an exemption would be necessary. Section 5.6, “UIUC Approach,” describes the specific methodology for determining regulatory applicability and includes table 5-1, which was addressed previously in this section of the SE.

2.2. NRC Staff Evaluation

The NRC staff reviewed TR table 4-2 and considers the proposed entry condition types (utilization facility, Class 104c. license, 10 CFR Part 50 license pathway, HTGR technology, timing of [CP] application, single unit site) appropriate to identify which regulations are not

³ The NRC staff did not issue the Draft White Paper as guidance to applicants or as staff guidance. The Roadmap ISG serves both of those functions.

applicable to UIUC due to its unique design and facility-specific attributes. The presence of entry conditions identified in existing regulations limit the applicability of regulations based on the facility type, the license class, the licensing pathway, the reactor technology, and other administrative factors. NRC guidance in Appendix B to DANU-ISG-2022-001 indicates that the regulations are considered not applicable if the entry conditions contained in the regulations are not met. Therefore, the NRC staff notes that consideration of the entry conditions characterized in TR table 4-2 and the process outlined in table 5-1 appears to be an appropriate framework to identify existing regulations applicable to the proposed UIUC MMR. However, the staff does not make any findings on this process because UIUC stated that it was provided for information only and not for NRC approval.

The NRC staff reviewed the defined RAGs used for sorting the results into specific categories. The NRC staff notes that the RAGs reflect the basis for non-applicability of certain regulations and the technical relevance of regulations determined to be applicable, except with respect to RAGs “3A Modified/partial” and “3B Meets intent.” With respect to RAG 3A, the staff notes that “significance” of a deviation from the regulations is not a consideration in whether an exemption would be needed. With respect to RAG 3B, “meeting the intent” of a regulation appears similar to one of the special circumstances that must be present for the Commission to consider exemptions from 10 CFR Part 50 regulations, namely in 10 CFR 50.12(a)(2)(ii), application of the regulation in the particular circumstances is not necessary to meet the underlying purpose of the regulation. However, the staff does not make any findings on the RAGs because they are part of the process that was provided for information only and not for NRC approval. The NRC staff evaluated the specific regulations where UIUC identified RAG “3A Modified/partial” or “3B Meets Intent,” in section 3, “Results,” of this SE to verify appropriate categorization of Part 50 regulations.

3. RESULTS

3.1. UIUC Presentation of Results

In section 6.0, “Summary of Planned Approach,” of the TR, the applicant stated that the results of the regulatory review are provided in Attachment 1, “Assignment of NRC Regulations to UIUC-MMR Regulation Applicability Groups,” and identified potential exemptions. Attachment 1 of the TR lists Chapter 1 of 10 CFR (Parts 1 to 199) to identify each Part and relevant individual regulation, lists the applicability of the regulatory requirements to the UIUC MMR design in accordance with the RAGs described above, and provides a basis for the RAG categorization. Attachment 1 does not address requirements in 10 CFR Part 52 because the selected licensing approach using the regulations of 10 CFR Part 50 to develop an application for a CP and subsequent OL do not reference 10 CFR Part 52.

In section 6.1, “Expected Exemptions,” the applicant determined that virtually all regulations that may have been considered for exemptions were found to not be applicable to the proposed UIUC MMR based on entry conditions. The applicant identified potential exemptions related to 10 CFR Part 73, “Physical Protection of Plants and Materials,” and 10 CFR Part 74, “Material Control and Accounting of Special Nuclear Material,” considering on-going rulemaking⁴ for

⁴ “Rulemaking for Enhanced Security of Special Nuclear Material,” Regulations.gov Docket ID: NRC-2014-0118, Regulation Identifier Number (RIN): 3150-AJ41. This rulemaking would amend the NRC's regulations to make generically applicable security requirements imposed in security orders after the events of September 11, 2001. The scope of this rulemaking could affect the physical protection capabilities and material accounting practices at nuclear plants and fuel cycle facilities.

protection of special nuclear material (SNM) that could affect the definitions of enrichment and quantities of SNM considered to be of strategic significance.

3.2. NRC Staff Evaluation

The NRC staff reviewed UIUC's assignment of RAGs for the MMR at UIUC as listed in Attachment 1. The NRC staff considers the lists of regulatory applicability determinations to be references that can inform the content of future licensing applications that will be subject to NRC staff review.

The NRC staff reviewed the UIUC RAGs against 10 CFR for consistency. The NRC staff compared the regulations identified as RAG "1 N/A," in Attachment 1 of the TR with regulations identified as not applicable to non-LWRs in table 1, "10 CFR Part 50 Requirements, as applicable to applications under Part 50 for non-LWRs," and table 3, "Other regulations that may apply to non-LWRs," of Appendix B to DANU-ISG-2022-01. The NRC staff found generally good agreement, with the exception that the TR identified additional regulations, such as those applicable only to Part 52 license or design certification requirements, that were not applicable based on the intended licensing approach for the UIUC MMR. The NRC staff also compared the regulations identified as RAG "2 N/A to NPUF," in the TR with regulations identified as not applicable to the Kairos Hermes Test Reactor based on applicability to power reactors only. The NRC staff concluded that the results were generally consistent between reports, with the exception of certain requirements discussed below and those that are applicable to test reactors but not research reactors, such as some provisions of 10 CFR Part 100, "Reactor Site Criteria."

In the table below, the NRC staff listed observations regarding the RAGs and the associated "Rationale/Justification/Comments" proposed by UIUC in Attachment 1 of the TR. If a particular regulation is not included in the NRC evaluation, this means the NRC staff has no comment on whether the regulation meets the RAG assigned by UIUC in Attachment 1 of the TR. The NRC staff did not individually evaluate comments providing justification for the RAGs assigned by UIUC, and, therefore, the NRC staff makes no finding or conclusion with regard to the specific comments as bases for the assigned RAG.

Regulation(s)	Observations
10 CFR 50.2	This regulation provides definitions of specific terms, such as reactor coolant pressure boundary (RCPB). UIUC assigned RAG “3B Meets intent,” to this regulation. In Appendix B to DANU-ISG-2022-01, the NRC staff indicated that definitions are not stand-alone requirements. The NRC staff determined that definitions, including changes to definitions, should be addressed in conjunction with the implementing regulation(s) that rely on the definitions.
10 CFR 50.36(c)(2)(ii)(A)	This regulation requires that installed instrumentation used to detect, and indicate in the control room, a significant abnormal degradation of the RCPB be subject to a limiting condition for operation in the facility technical specifications. UIUC indicates that the intent of this regulation would be met (i.e., RAG “3B Meets intent”). UIUC provided notes justifying the RAG “3B Meets intent,” on the basis that the principal design criteria (PDC) for modular high temperature gas-cooled reactors in Regulatory Guide 1.232 (Reference 7) replace “reactor coolant pressure boundary” with “helium pressure boundary” in select PDC. This change relates to table 5, “Areas with anticipated exemptions,” of Appendix B to DANU-ISG-2022-01, which identifies RCPB as a topical area that has particular safety significance for LWRs because the RCPB acts as a fission product barrier and is defined specifically for LWRs in 10 CFR 50.2. In this application, the use of RAG “3B Meets intent,” suggests an exemption may be necessary to apply alternate criteria in 10 CFR 50.36. In table 5 of Appendix B to DANU-ISG-2022-01, the NRC staff recommended consideration of a rule of particular applicability to implement alternatives to defined terms in this regulation.
10 CFR 74.1, 74.2, 74.4 to 8, 74.11, 74.13, 74.15, 74.17, 74.19, 74.81 to 84	Attachment 1 to the TR places these regulations in the RAG “2 N/A to NPUF” without clear justification. These regulations relate to control and accounting of SNM, do not include entry conditions related to power reactors and are identified as applicable to the Kairos Hemes Test Reactor in KP-TR-004-NP, Revision 4. The NRC staff recognizes that UIUC identified 10 CFR Part 74 as an area subject to ongoing rulemaking where the applicant may seek exemption(s) and notes that 10 CFR 74.17 and 74.19 have other entry conditions that may not apply to the UIUC MMR for reasons other than licensing as an NPUF.

The NRC staff reviewed the regulations that UIUC designated as RAG “4 Request exemption.” The NRC concludes that the regulations designated as RAG “4 Request exemption” in 10 CFR Part 73 and 10 CFR Part 74 may apply (in whole or in part) to the licensing of the UIUC MMR. The NRC staff’s consideration of whether an exemption is appropriate or can be justified will await consideration of detailed information submitted in a license application or specific exemption request. This SE does not reach any conclusion as to the acceptability or viability of any exemption request. The evaluation of whether an exemption should be granted would occur after the submittal of a specific exemption request and would be documented in the SE associated with a future licensing submittal.

Regardless of the conclusions with respect to the current NRC regulations, the NRC staff will evaluate a future application against the Commission's regulations at the time of a license application submittal. The positions stated in this SE do not override the requirements in the regulations themselves. During detailed review of an application, subsequent NRC analysis of its regulations in the context of the more complete design information in the application could take precedence over the positions stated in this SE.

4. LIMITATIONS AND CONDITIONS

An applicant may reference the TR for use as applied to the applicant's facility only if the applicant demonstrates compliance with the following limitations and conditions:

1. Applications referencing this TR must be for a type Class 104c. license for a non-power research reactor, consistent with 10 CFR 50.21(c) and 10 CFR 50.22.
2. The SE applies only to a reactor located at UIUC with a design of the type described in section 2.0 of the TR, which includes the following key attributes:
 - a. A functional containment design using TRISO fuel enriched to less than 20 percent U-235.
 - b. An inert, gaseous, and non-condensable coolant.
 - c. A pressure boundary maintaining the coolant above atmospheric pressure during normal operation.

The NRC staff makes no findings with respect to the acceptability of the design.

3. The NRC staff's approval of this TR does not endorse the use of Attachment 1 to the TR as a final comprehensive list of applicable regulations used by the NRC to evaluate a future UIUC MMR application. Rather, Attachment 1 to the TR serves only as identification of generally applicable regulations for the applicant's use in developing an application for a CP or OL under 10 CFR Part 50. The NRC staff will determine the full scope of regulations that apply to a future application at the time of submittal based on the regulations that are in effect at that time. For example, regulatory applicability may be affected by future regulatory changes. At the time of approval of this evaluation, the applicability statements in Attachment 1 to the TR are generally correct for the described UIUC MMR.
4. This SE does not override the requirements within the regulations themselves. The information provided in this TR was used to provide an assessment of applicability based on the information available to the NRC staff at the time of the review and represents one potentially adequate method for complying with the regulations. If at the time of the detailed review of an application the applicability determinations noted here conflict with any regulatory requirements or subsequent NRC interpretations of its regulations, those requirements and interpretations would take precedence over the positions in this TR.

CONCLUSION

The NRC staff determined that Attachment 1 to the TR identified a generally acceptable list of applicable regulatory requirements for use in developing a license application for the described UIUC MMR research reactor, subject to the limitations and conditions listed in section 4.0 of this SE. With the exception of the items identified in section 3.2 above, the applicability determinations in Attachment 1 generally identify regulations applicable to the proposed UIUC MMR. A more detailed evaluation of applicable regulations and other necessary requirements for licensing the UIUC MMR will be conducted following the

completion of the facility's design and submittal of a license application. A final NRC staff determination regarding the applicable regulations will await review at the time of a license application submittal based on the regulations that are in effect at that time.

REFERENCES

1. US Nuclear Regulatory Commission (NRC), "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content," NUREG-1537, Part 1, February 1996, ML042430055.
2. USNRC, "Updated NRC Staff Draft White Paper - Analysis of Applicability of NRC Regulations for Non-Light Water Reactors," July 2021, ML21175A287.
3. USNRC, Division of Advanced Reactors and Non-Power Production and Utilization Facilities (DANU), Interim Staff Guidance (ISG), DANU-ISG-2022-01, "Review of Risk-Informed, Technology-Inclusive Advanced Reactor Applications—Roadmap," March 2024, ML23277A139.
4. Kairos Power LLC, "Regulatory Analysis for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor," Revision 4, January 18, 2022, ML22018A159.
5. Kairos Power LLC, Approved Version of - "Regulatory Analysis for The Kairos Power Fluoride Salt-Cooled High Temperature Reactor," Revision 4, including NRC Safety Evaluation, June 8, 2022, ML22159A356.
6. USNRC, SECY-18-0096, "Functional Containment Performance Criteria for Non-Light-Water-Reactors," September 28, 2018, ML18114A546.
7. USNRC, Regulatory Guide 1.232, "Guidance for Developing Principal Design Criteria for Non-Light Water Reactors," Revision 0, April 2018, ML17325A611.

Principal Contributors: S. Jones, NRR
P. Torres, NRR
B. Travis, NRR

Date: July 25, 2024

From: Paulette Torres
Sent: Wednesday, October 18, 2023 11:57 AM
To: Brooks, Caleb
Cc: Edward Helvenston; Kelly Sullivan; Patrick Boyle; Josh Borromeo; Foyto, Les; Grunloh, Timothy P; Greg Oberson (He/Him); Steve Jones
Subject: Action: Request for Additional Information Regarding UIUC Regulatory Applicability Topical Report Release 02
Attachments: RAI regarding UIUC Regulatory Applicability TR Release 02.pdf

Dear Dr. Brooks:

By letter dated December 9, 2022 (Agencywide Documents Access and Management System (ADAMS) Package Accession No. ML22343A282), University of Illinois at Urbana-Champaign (UIUC or the applicant) submitted Release 1 of Topical Report (TR), "University of Illinois Urbana-Champaign High Temperature Gas-cooled Research Reactor: Applicability of Nuclear Regulatory Commission Regulations," for the U.S. Nuclear Regulatory Commission (NRC) staff's review.

The staff held a public meeting with the applicant on June 8, 2023, to discuss the NRC staff's preliminary questions on the UIUC applicability of NRC regulations topical report (ADAMS Accession No. ML23159A036). The staff prepared a list of discussion topics and UIUC prepared slides addressing the topics (ADAMS Accession No. ML23151A544 and ML23158A252, respectively). Based on discussions during that meeting, UIUC stated that a revised TR would be submitted. The applicant forwarded the revised TR, Release 2, by letter dated August 30, 2023 (ADAMS Accession No. ML23242A329).

The U.S. Nuclear Regulatory Commission (NRC) staff identified additional information needed to continue its review of the topical report, as described in the enclosed request for additional information (RAI). As discussed on email dated September 19, 2023 (ADAMS Accession No. ML23262B024), provide a response to the RAI or a written request for additional time to respond, including the proposed response date and a brief explanation of the reason, within 60 days of this email. Following receipt of the complete response to the RAI, the NRC staff will continue its review of the topical report.

If you have any questions regarding the NRC staff's review or if you intend to request additional time to respond, please contact me at (301) 415-5656 or by electronic mail at Paulette.Torres@nrc.gov.

Sincerely,

Paulette Torres, Project Manager
Non-Power Production and Utilization Facility Licensing Branch
Division of Advanced Reactors and Non-Power Production and Utilization Facilities
Office of Nuclear Reactor Regulation

Project No. 99902094
EPID: L-2022-NFN-0008
Enclosure: As stated
cc: GovDelivery Subscribers

Concurrence on RAI Enclosure

OFFICE	NRR/DANU/UNPL/PM	NRR/DANU/UTB1/BC	NRR/DANU/UNPL/BC	NRR/DANU/UNPL/PM
NAME	PTorres	GOberson	JBorromeo	PTorres
DATE	10/10/2023	10/13/2023	10/17/2023	10/18/2023

Hearing Identifier: NRR_DRMA
Email Number: 2279

Mail Envelope Properties (SA0PR09MB7036C9918A6D8ED29E5D1279FED5A)

Subject: Action Request for Additional Information Regarding UIUC Regulatory
Applicability Topical Report Release 02
Sent Date: 10/18/2023 11:56:37 AM
Received Date: 10/18/2023 11:56:00 AM
From: Paulette Torres

Created By: Paulette.Torres@nrc.gov

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Files	Size	Date & Time
MESSAGE	2534	10/18/2023 11:56:00 AM
RAI regarding UIUC Regulatory Applicability TR Release 02.pdf		110399

Options

Priority: Normal
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:

OFFICE OF NUCLEAR REACTOR REGULATION
REQUEST FOR ADDITIONAL INFORMATION
APPLICABILITY OF NUCLEAR REGULATORY COMMISSION
REGULATIONS TOPICAL REPORT
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
PROJECT NO. 99902094

The U.S. Nuclear Regulatory Commission (NRC) staff reviewed the “University of Illinois Urbana-Champaign (UIUC) High Temperature Gas-cooled Research Reactor: Applicability of Nuclear Regulatory Commission Regulations,” Topical Report (TR), Release 02, dated August 30, 2023 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML23242A329) for compliance with the appropriate regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) using the following guidance and standard(s):

- NUREG-1537 Part 1, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Format and Content,” issued February 1996 (ADAMS) Accession No. ML042430055)
- NUREG-1537 Part 2, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Standard Review Plan and Acceptance Criteria,” issued February 1996 (ADAMS Accession No. ML042430048)

Based on its review, the NRC staff requires the following additional information to continue its review of the UIUC TR.

- 1) Section 3.1 of the UIUC TR, titled “Applicability of Existing Regulations to Non-LWR Technologies,” states under the bullet, “Staffing Requirements,” that “Staffing for research reactors is not required to meet 10 CFR 50.54.” However, Attachment 1 to the UIUC TR indicates that 10 CFR 50.54(m)(1) regarding the presence or availability of a senior operator applies as is. Please clarify the intended applicability of 10 CFR 50.54(m)(1) to the proposed research reactor.
- 2) Section 4.1 of the UIUC TR, titled “Applicability Identified in Regulations via Entry Conditions,” included a statement that “some regulations define limited applicability in their titles.” The section is not complete because it does not address the scope of review in determining the applicability conditions for a regulation. The Federal Register citation associated with each regulation provides a statement of considerations during development of the regulation, the text of the regulation contains the specific requirements, and the title of the regulation briefly summarizes the scope. These three sources may not provide equivalent and identical detail regarding applicability of the regulation. Please clarify how all sources of information regarding applicability (i.e., entry conditions as described in the UIUC TR) would be evaluated and any conflicts resolved.
- 3) Figure 4-1, “Process for Determining Applicability of NRC Regulation,” indicates comparisons of determinations made using entry conditions would be made against other

documents as confirmatory actions, including comparisons against the list of regulations identified by the staff as applicable to research reactors in Appendix A to NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors - Format and Content," which was published in February 1996. Please clarify how regulations would be screened for changes implemented after the issue date of documents identified for use in comparisons to ensure validity of the comparisons.

- 4) Table 4.1 of the UIUC TR describes the category of "2 N/A to NPUF" used to indicate regulations that do not apply to NPUFs on the following basis: "NPUFs do not need to meet regulations that have entry conditions pertaining to "power reactor." Based upon UIUC qualifying for a Class 104(c) license, which is a non-power reactor, the power reactor regulations are not applicable." Section 4.2.1, Item 2, and Section 6.1.1 of the UIUC TR identify 10 CFR 50.68, Criticality accident requirements, as having an entry condition of nuclear power reactor. Further, Table 5.1, "Steps in Process to Evaluate NRC Regulation Applicability to UIUC MMR," of the UIUC TR indicates that, after completion of the review based on entry conditions, the results would be compared with other sources of relevant information including the Kairos Power LLC Topical Report, "Regulatory Analysis for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor – TR," Revision 4 (KP-TR-004, Rev. 4) (ML22018A161), and differences would be reconciled. The Kairos TR identifies 10 CFR 50.68 as not applicable to the Kairos test reactor on the rationale that the test reactor is not a power reactor, and that 10 CFR 70.24, Criticality accident requirements, applies for criticality monitoring. Please clarify how the categorization process, including comparison with other relevant sources of information, was applied to 10 CFR 50.68 and how paragraph (b) (7) was identified as under consideration for an exemption.
- 5) Per 10 CFR 50.34(a)(3), the application for construction permit must include the preliminary design of the facility, including (i) the principal design criteria (PDC) and (ii) the design bases and relationship of the design bases to the PDC. Following the statement regarding principal design criteria in 10 CFR 50.34(a)(3)(i), the regulation states, "Appendix A, General Design Criteria for Nuclear Power Plants, establishes minimum requirements for the principal design criteria for watercooled nuclear power plants similar in design and location to plants for which construction permits have previously been issued by the Commission and provides guidance to applicants for construction permits in establishing principal design criteria for other types of nuclear power units." Table 5.1, "Steps in Process to Evaluate NRC Regulation Applicability to UIUC MMR," of the UIUC TR indicates that, after completion of the review based on entry conditions, the results would be compared with other sources of relevant information, including Appendix A, "Applicability of Selected Regulations in Title 10, Chapter I, of the Code of Federal Regulations to Non-Power Reactors," of NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors - Standard Review Plan and Acceptance Criteria," Part I, and differences reconciled. Appendix A to NUREG-1537 identifies 10 CFR 50.34(a)(3) as applicable to non-power reactors. Please clarify how the categorization process, including comparison with other relevant sources of information, was applied to 10 CFR 50.34(a)(3) to determine applicability subgroup "1 N/A" for 10 CFR 50.34(a)(3)(i), as shown in Attachment 1 to the UIUC TR.
- 6) The regulations at 10 CFR 50.34 (g) and 10 CFR 50.44(d) related to combustible gas control state that those requirements apply to all applicants for a reactor construction permit or operating license whose application is submitted after October 16, 2003. Table 5.1, "Steps in Process to Evaluate NRC Regulation Applicability to UIUC MMR," of the UIUC TR indicates that, after completion of the review based on entry conditions, the results would be

compared with other sources of relevant information including the Kairos Topical Report, KP-TR-004, Rev. 4, and differences would be reconciled. The Kairos TR identifies 10 CFR 50.34(g) and 10 CFR 50.44(d) as applicable to the Kairos test reactor. The current version of 10 CFR 50.44, including all of paragraph(d), was issued in 2003, which is after the publication of NUREG-1537. Please clarify how the category of "2 N/A to NPUF" and the note "N/A per 1537 App. A" was assigned to 10 CFR 50.34(g) and 10 CFR 50.44 using the categorization process described in Section 4 and Table 5.1 of the UIUC TR.

December 11, 2023

Docket No.: 99902094
U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

Subject: Written communication as specified by 10 CFR 50.4 regarding responses to the “University of Illinois at Urbana-Champaign – Request for Additional Information – Applicability of Nuclear Regulatory Commission Regulations Topical Report,” dated October 18, 2023

By letter dated December 9, 2022 (ML22343A283), the University of Illinois Urbana-Champaign (UIUC) submitted the Topical Report (TR), “University of Illinois Urbana-Champaign High Temperature Gas-cooled Research Reactor: Applicability of Nuclear Regulatory Commission Regulations” (ML22343A284) to the U.S. Nuclear Regulatory Commission (NRC) for acceptance review and generation of a review schedule. A 12 month review for the TR was requested and approval of the methodology used and determinations of applicability/non-applicability of specific regulations identified in the TR as the licensing basis for the UIUC research reactor. NRC approval of the process for treatment of exemptions was also requested; approval for needed exemptions will be requested as part of the application submittal process.

By email dated February 9, 2023 (ML23020A284), the NRC provided UIUC the completeness determination for the TR. Based on a preliminary review of the TR, the NRC staff determined that it provided sufficient information for the NRC staff to begin a detailed technical review.

On May 31, 2023, the NRC provided UIUC a list of discussion items regarding the TR titled: ‘UIUC Topical Report: “Applicability of Nuclear Regulatory Commission Regulations” Discussion Topics’ (ML23151A544).

On June 8, 2023, a public meeting (ML23159A036) was held between NRC and UIUC project staff to discuss the items that were listed in the document titled ‘UIUC Topical Report: “Applicability of Nuclear Regulatory Commission Regulations” Discussion Topics.’ Based on discussions during that meeting, UIUC agreed to provide the NRC with a new revision of the TR to address the NRC staff’s questions.

By letter dated August 30, 2023 (ML23242A330), UIUC submitted a revised version (Release 02) of the “University of Illinois Urbana-Champaign High Temperature Gas-cooled Research Reactor: Applicability of Nuclear Regulatory Commission Regulations” TR (ML23242A331) to the NRC.

By email dated October 18, 2023 (ML23291A332), the NRC staff requested additional information and clarification regarding Release 02 of the TR in the form of six (6) request for additional information (RAI). The RAI, and UIUC’s responses to the RAI, are enclosed as Attachment 1.

The responses to the RAI do not contain any commercially sensitive information and can be posted for unrestricted access by the public. Questions or other requests related to the RAI responses should be directed to Caleb Brooks at csbrooks@illinois.edu or (217) 265-0519.

I declare under penalty of perjury that the foregoing is true and correct. Executed on December 11, 2023.

Sincerely,



Caleb S. Brooks, Ph.D.
Associate Professor
University of Illinois at Urbana-Champaign
Department of Nuclear, Plasma, and Radiological Engineering
Talbot Laboratory, Room 111C, MC-234
104 South Wright St, Urbana, IL 61801
TEL 217-265-0519 | FAX 217-333-2906
csbrooks@illinois.edu

Attachment:

1. Responses to the “University of Illinois at Urbana-Champaign – Request for Additional Information – Applicability of Nuclear Regulatory Commission Regulations Topical Report,” dated October 18, 2023

Cc:

UIUC

Tim Grunloh

Les Foyto

USNC

Daniel Stout

Zackary Rad

Jeff Perry

NRC

Edward Helvenston

ATTACHMENT 1

Responses to the “University of Illinois at Urbana-Champaign – Request for Additional Information – Applicability of Nuclear Regulatory Commission Regulations Topical Report,” dated October 18, 2023

RAI-1: *Section 3.1 of the UIUC TR, titled “Applicability of Existing Regulations to Non-LWR Technologies,” states under the bullet, “Staffing Requirements,” that “Staffing for research reactors is not required to meet 10 CFR 50.54.” However, Attachment 1 to the UIUC TR indicates that 10 CFR 50.54(m)(1) regarding the presence or availability of a senior operator applies as is. Please clarify the intended applicability of 10 CFR 50.54(m)(1) to the proposed research reactor.*

UIUC will satisfy 50.54(m)(1), as NUREG-1537 Appendix A indicates 50.54(m)(1) is applicable, as noted in Attachment 1 to the UIUC TR. To avoid confusion, the Staffing Requirements example in Section 3.1 will be removed in the next revision of the TR.

RAI-2: *Section 4.1 of the UIUC TR, titled “Applicability Identified in Regulations via Entry Conditions,” included a statement that “some regulations define limited applicability in their titles.” The section is not complete because it does not address the scope of review in determining the applicability conditions for a regulation. The Federal Register citation associated with each regulation provides a statement of considerations during development of the regulation, the text of the regulation contains the specific requirements, and the title of the regulation briefly summarizes the scope. These three sources may not provide equivalent and identical detail regarding applicability of the regulation. Please clarify how all sources of information regarding applicability (i.e., entry conditions as described in the UIUC TR) would be evaluated and any conflicts resolved.*

Section 4.1 is primarily a description of how entry conditions are used in 10 CFR Parts 1 to 199. Figure 4-1 is a high-level summary of the process used to prepare Attachment 1 of the TR. Table 5-1 of the TR provides a more detailed discussion of the individual steps used to determine applicability.

The Federal Register (FR) statements of considerations were consulted as part of the final reconciliation of discrepancies, as noted in the right-hand column of Step 5 of Table 5-1: “federal register rulemaking narratives.” Use of the FR was most frequently needed when step 4 found a regulation that appeared to be inconsistent with NUREG-1537 Appendix A. If a FR rulemaking reference at the end of the regulation included one after the NUREG-1537 manuscript completed date (February 1996), then the FR notices were reviewed.

Although the FR rulemaking notices contain details not readily available in other documentation, they are focused on the NRC regulatory concerns at the time of rulemaking and could have inadvertently included or excluded consideration of future non-LWR reactors. Also, there are known cases where applicability of regulations is interpreted in NRC guidance, such as requirements under 10 CFR 50.34(f) (i.e., Three Mile Island accident action items), which would only be applicable for Part 52 applications because Part 50 has entry conditions that restrict applicability but for direction provided in the Staff Requirements Memorandum for SECY-15-0002.

In the few instances where “equivalent and identical detail regarding applicability of the regulation” were an issue, the determination of appropriate applicability of a regulation was made by UIUC in consultation with USNC. The main example of such an item is how to interpret criticality considerations in 10 CFR 50.68 versus 10 CFR 70.24 for a research reactor using uranium enriched between 5 and 20 percent, for which the possible need for an exemption is noted in TR Section 6.1.1, consistent with Table 5 of reference 12 of the TR.

ATTACHMENT 1

Please note that all sources of information regarding applicability were not evaluated, as that could be interpreted to include Commissioner vote sheets, Differing Professional Opinions, draft versions of rulemaking, other standard review plans, etc.

RAI-3: *Figure 4-1, “Process for Determining Applicability of NRC Regulation,” indicates comparisons of determinations made using entry conditions would be made against other documents as confirmatory actions, including comparisons against the list of regulations identified by the staff as applicable to research reactors in Appendix A to NUREG-1537, Part 1, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors - Format and Content,” which was published in February 1996. Please clarify how regulations would be screened for changes implemented after the issue date of documents identified for use in comparisons to ensure validity of the comparisons.*

If an inconsistency between entry conditions for a regulation and its applicability per NUREG-1537 Appendix A, the Federal Register (FR) rulemaking references at the end of the regulation were checked for any occurring after the NUREG-1537 manuscript completed date (February 1996). If found, the FR notices were reviewed.

As an example, NUREG-1537 Appendix A shows all of 10 CFR 50.34(a)(1) as applicable, but (a)(1)(ii) has an entry condition (“Stationary power reactor applicants for a construction permit who apply on or after January 10, 1997”). Therefore, it appeared that § 50.34(a)(1) changed after 1996. Ascertaining the origin of this change required searching for the appropriate FR notice because the attributions at the end of 50.34 listed seven revisions since 1996. However, none of these included the change. After further searching of changes to 50.34, the appropriate reference was found (Volume 71, Number 48, March 13, 2006, pages 12782-12932) on page 12862. Page 12803 of the rulemaking states, “Section 50.34(a) currently provides the requirements for the technical contents of an application for a stationary power reactor...” The stationary power reactor entry conditions of § 50.34 were, therefore, changed in 2006 which post-dates NUREG 1537, thus eliminating the conflict.

Going forward, UIUC will routinely monitor FR Notices indicating changes to Title 10 Parts 1 through 199 by subscribing to FederalRegister.gov. Where proposed rulemaking could affect regulations applicable to the UIUC reactor, the applicability and impact of the rulemaking will be assessed through a process similar to that described in Table 5.1.

RAI-4: *Table 4.1 of the UIUC TR describes the category of “2 N/A to NPUF” used to indicate regulations that do not apply to NPUFs on the following basis: “NPUFs do not need to meet regulations that have entry conditions pertaining to “power reactor.” Based upon UIUC qualifying for a Class 104(c) license, which is a non-power reactor, the power reactor regulations are not applicable.” Section 4.2.1, Item 2, and Section 6.1.1 of the UIUC TR identify 10 CFR 50.68, Criticality accident requirements, as having an entry condition of nuclear power reactor. Further, Table 5.1, “Steps in Process to Evaluate NRC Regulation Applicability to UIUC MMR,” of the UIUC TR indicates that, after completion of the review based on entry conditions, the results would be compared with other sources of relevant information including the Kairos Power LLC Topical Report, “Regulatory Analysis for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor – TR,” Revision 4 (KP-TR-004, Rev. 4) (ML22018A161), and differences would be reconciled. The Kairos TR identifies 10 CFR 50.68 as not applicable to the Kairos test reactor on the rationale that the test reactor is not a power reactor, and that 10 CFR 70.24, Criticality accident requirements, applies for criticality monitoring. Please clarify how the categorization process, including comparison with other relevant sources of information, was applied to 10 CFR 50.68 and how paragraph (b) (7) was identified as under consideration for an exemption.*

ATTACHMENT 1

The UIUC reactor will be a graphite-moderated, high-temperature, gas-cooled, non-power research reactor fueled with high assay low-enriched uranium. The interaction between 10 CFR 50.68 and 70.24 is not clear:

- § 50.68 applies to power reactors.
- § 70.24 requires a criticality alarm system unless § 50.68(b) is met.
- 50.68(b)(7) requires fuel with U-235 enrichment of no more than five percent.
- § 70.24(d)(2) states an “exemption from § 70.24 held by a licensee who thereafter elects to comply with requirements of paragraph (b) of 10 CFR 50.68 does not exempt that licensee from complying with any of the requirements in § 50.68, but shall be ineffective so long as the licensee elects to comply with § 50.68.”
- Consistent with the above, NUREG-1537 Appendix A does not list § 50.68 but does list § 70.24 as applicable to non-power reactors.
- Table 5 of the “Updated NRC Staff Draft White Paper Analysis of Applicability of NRC Regulations for Non-Light Water Reactors” (July 2012) states that the requirements in § 50.68(b) were added “to provide clear methods for precluding criticality that would obviate the need for monitoring criticality in stored fuel” and that “non-LWR applicants could provide similar criteria for specific non-LWR fuel designs as necessary through exemptions. In the absence of an exemption, a non-LWR application will be required to describe criticality monitoring required by 10 CFR 70.24.”

More specifically, the entry condition (EC) in 10 CFR 50.68(a) requires compliance by holders of nuclear power reactor permits and licenses under 10 CFR 50 and 52 with either 10 CFR 70.24 or § 50.68(b), which lays out requirements in lieu of a criticality monitoring system in accordance with § 70.24. § 50.68(b)(7) restricts the maximum U-235 enrichment of fresh fuel assemblies to five percent by weight.

10 CFR 70 pertains to domestic licensing of special nuclear material. § 70.24 requires criticality accident monitoring for licenses authorizing more than 700 grams of U-235 (or half that mass if massive graphite moderators or reflectors are present). § 70.24(d)(1) states that requirements of the preceding portions of § 70.24 do not apply to holders of permits or licenses for nuclear power reactors under 10 CFR 50 or 52 if the holder complies with 10 CFR 50.68(b).

Thus, it appears that power reactors have an option of complying with § 50.68(b) as an alternative to § 70.24, but that non-power reactors do not. Presumably, though, UIUC could commit to meeting 50.68(b), even though not required, but § 50.68(b)(7) limits enrichment to no more than five percent. Therefore, seeking an exemption may be needed.

Additionally, based on the statement made in the July 2021 draft staff white paper, an exemption might be needed because the UIUC reactor is a non-LWR.

UIUC and USNC will evaluate if an exemption from any specific provisions of § 50.68(b) or § 70.24 as part of the Construction Permit Application.

RAI-5: Per 10 CFR 50.34(a)(3), the application for construction permit must include the preliminary design of the facility, including (i) the principal design criteria (PDC) and (ii) the design bases and relationship of the design bases to the PDC. Following the statement regarding principal design criteria in 10 CFR 50.34(a)(3)(i), the regulation states, “Appendix A, General Design Criteria for Nuclear Power Plants, establishes minimum requirements for the principal design criteria for watercooled nuclear power

ATTACHMENT 1

plants similar in design and location to plants for which construction permits have previously been issued by the Commission and provides guidance to applicants for construction permits in establishing principal design criteria for other types of nuclear power units.” Table 5.1, “Steps in Process to Evaluate NRC Regulation Applicability to UIUC MMR,” of the UIUC TR indicates that, after completion of the review based on entry conditions, the results would be compared with other sources of relevant information, including Appendix A, “Applicability of Selected Regulations in Title 10, Chapter I, of the Code of Federal Regulations to Non-Power Reactors,” of NUREG-1537, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors - Standard Review Plan and Acceptance Criteria,” Part I, and differences reconciled. Appendix A to NUREG-1537 identifies 10 CFR 50.34(a)(3) as applicable to non-power reactors. Please clarify how the categorization process, including comparison with other relevant sources of information, was applied to 10 CFR 50.34(a)(3) to determine applicability subgroup “1 N/A” for 10 CFR 50.34(a)(3)(i), as shown in Attachment 1 to the UIUC TR.

As discussed below, UIUC has concluded that Appendix 1 to the TR should be revised to show 10 CFR 50.34(a)(3) as "Applicable as is" and delete the rows for 10 CFR 50.34(a)(3)(i) and (ii)."

The following entry conditions (ECs) and other applicability guidance are relevant.

- 10 CFR 50, Appendix A –
 - The title is General Design Criteria for Nuclear Power Plants, which is an EC excluding non-power reactors.
 - The second paragraph states that the General Design Criteria
 - “establish minimum requirements for the principal design criteria for water-cooled nuclear power plants similar in design and location to plants for which construction permits have been issued by the Commission. The General Design Criteria are also considered to be generally applicable to other types of nuclear power units and are intended to provide guidance in establishing the principal design criteria for such other units.”
 - The Definitions and Explanations section states “A nuclear power unit means a nuclear power reactor and associated equipment necessary for electric power generation and includes those structures, systems, and components required to provide reasonable assurance the facility can be operated without undue risk to the health and safety of the public.”
- § 50.34(a)(3)(i) – ECs limit applicability of Appendix A to watercooled power reactors and “for other types of nuclear power units.”
- NUREG-1537 Appendix A lists § 50.34(a)(3) as applicable, but not Appendix A of 10 CFR 50.
- RG 1.232 states that 10 CFR 50 Appendix A is not applicable to non-light water reactors. The last Federal Register (FR) revision citation is in 2007, whereas RG 1.232 was issued in April 2018 and is, therefore, the most current guidance.

In making the determination that § 50.34(a)(3)(i) was not applicable, UIUC concluded that 10 CFR 50 Appendix A was limited to water-cooled power reactors by its own ECs and RG 1.232 and that § 50.34(a)(3)(i) was limited to power reactors by its ECs. UIUC recognizes that the safety analysis reports must identify principal design criteria and considered that this was required by § 50.34(a)(3)(ii), which states, “The design bases and the relation of the design bases to the principal design criteria.” UIUC agrees that § 50.34(a)(3)(i) can be parsed into first a requirement to provide the principal design criteria and second into an informational statement about the Appendix A General Design Criteria. With this interpretation,

ATTACHMENT 1

applicability of § 50.34(a)(3) would be “3 Applicable as is” because no distinction needs to be made in regard to 50.34(a)(3)(i) and (ii).

***RAI-6:** The regulations at 10 CFR 50.34 (g) and 10 CFR 50.44(d) related to combustible gas control state that those requirements apply to all applicants for a reactor construction permit or operating license whose application is submitted after October 16, 2003. Table 5.1, “Steps in Process to Evaluate NRC Regulation Applicability to UIUC MMR,” of the UIUC TR indicates that, after completion of the review based on entry conditions, the results would be compared with other sources of relevant information including the Kairos Topical Report, KP-TR-004, Rev. 4, and differences would be reconciled. The Kairos TR identifies 10 CFR 50.34(g) and 10 CFR 50.44(d) as applicable to the Kairos test reactor. The current version of 10 CFR 50.44, including all of paragraph(d), was issued in 2003, which is after the publication of NUREG-1537. Please clarify how the category of “2 N/A to NPUF” and the note “N/A per 1537 App. A” was assigned to 10 CFR 50.34(g) and 10 CFR 50.44 using the categorization process described in Section 4 and Table 5.1 of the UIUC TR.*

10 CFR 50.34(g) requires inclusion of analyses and descriptions of the equipment and systems required by § 50.44 as a part of an application for a construction permit or operating license. Therefore, § 50.34(g) is dependent on the applicability determination of § 50.44.

The combustible gas regulations in § 50.44 are titled “Combustible gas control for nuclear power reactors.” As the entry condition (EC) of the title limits applicability to power reactors, § 50.44 would not be relevant for the UIUC research reactor. Individual requirements within the regulation have more specific ECs, but they do not alter the limitation to power reactors:

- § 50.44(a) – definitions of types of containment atmospheres
- § 50.44(b) – currently licensed reactors
- § 50.44(b)(2) - LWRs with Mark I or II containments or Mark III containments
- § 50.44(b)(3) – BWRs with Mark III containments or all PWRs
- § 50.44(b)(4) – equipment for monitoring oxygen and hydrogen in containments
- § 50.44(b)(5) – EC for holders of operating licenses of Mark III BWRs or PWRs with ice condenser containments
- § 50.44(c) – EC for future water-cooled reactor applicants and licensees (further restricted by footnote 2 to those water reactors with fuel cladding with potential to produce combustible gases).
- § 50.44(d) – EC for future non water-cooled reactor applicants and licensees and certain water-cooled reactor applicants and licensees of any type of license or permit under either this part (i.e., Part 50) or Part 52 “for non water-cooled reactors and water-cooled reactors that do not fall within the description in paragraph (c), footnote 1 of this section, any of which are issued after October 16, 2003.” Paragraph (c) has a footnote 2 (but no footnote 1).

The determination of non-applicability of § 50.44 was made on the basis of the EC in the title limiting applicability to power reactors. The EC for § 50.44(d) was judged to be subordinate to the title. This was further supported by statements in the Federal Register notice issuing 50.44 (Federal Register, Vol. 68, No. 179, 9/16/2003, page 54123):

“SUMMARY: The Nuclear Regulatory Commission (NRC) is amending its regulations for combustible gas control in power reactors applicable to current licensees and is

ATTACHMENT 1

consolidating combustible gas control regulations for future reactor applicants and licensees.”

In discussion of the rulemaking, the NRC referenced SECY-01-0162, “Staff Plans for Proceeding with the Risk-Informed Alternative to the Standards for Combustible Gas Control Systems in Light-Water-Cooled Power Reactors in 10 CFR 50.44,” dated August 23, 2001. This SECY states in the title that it applies to power reactors and, like 10 CFR 50.44 and its Federal Register notice, does not discuss extension to non-power reactors. The Staff Requirements Memorandum dated December 31, 2001, provides no additional information on applicability.

The combustible gas risk of an MMR is low. For light water reactors, substantial quantities of hydrogen could be released by the zirconium fuel clad due to exothermic reaction with steam/water at temperatures above 1800 °F. Because the secondary heat transfer medium in the UIUC reactor will be molten salt, not water, there is limited water to support the reaction. In addition, most of the gas in the reactor vessel is inert helium. Combustion of solid graphite blocks is very slow because of limited surface area.

The evaluation process informs UIUC’s decision regarding applicability of each regulation, but the final determination is made based on assessment of the UIUC project to license a micro HTGR as a research reactor.

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CONFIGURATION CONTROL SUMMARY

Document Revision History

Document No.	Rel.	Date	Prepared By	Revision Description
IMRDD-MMR-22-04	01	12/08/2022	MPR Associates, Inc.	Initial Issue for NRC review
IMRDD-MMR-22-04	02	08/30/2023	MPR Associates, Inc.	Revision to address NRC questions provided to UIUC on 05/31/2023, subsequently discussed during an NRC public meeting on 06/08/2023.
IMRDD-MMR-22-04	03	02/28/2024	USNC	Revision to include UIUC RAI responses to the NRC on 12/11/2023 and NRC meeting information from 01/24/2024.
IMRDD-MMR-22-04	04	03/15/2024	USNC	<ul style="list-style-type: none"> Removed request for methodology approval. Removed Figure 4-1. Process for Determining Applicability of NRC Regulation. Section 5.6 UIUC Approach improved to include review of subparts to regulation for evaluating entry conditions.

Revision Summary for Release 03

RAI-1	Section 3.1 (para. 3): Clarified the second example under paragraph 3 for containment and confinement features of the MMR design to limit the release of radioactivity to meet the radiological dose limits and removed the third example of "Staffing Requirements".
RAI-2 & Public Meeting Action	<p>Section 4.1 (para. 4) and Table 5.1 (Step 1 & 5): Changes made to expand beyond the use of a regulation's title as a sole means for determining the applicability of a regulation to the UIUC MMR.</p> <p>Section 6.1.1, formerly; "Criticality Accident Requirements": Removed this section as an expected exemption due to changing the applicability of 10 CFR 70.24 to "Applicable as is".</p> <p>Attachment 1 applicability determination changes:</p> <ul style="list-style-type: none"> §50.68(b)(7): "2 N/A to NPUF" – Criticality requirements addressed through compliance with §70.24. §70.24: "3 Applicable as is"
RAI-3	Section 1.3: Statement added to clarify how UIUC will monitor future changes to Title 10 Parts 1 through 199.
Update	Section 4.7: Added paragraph 2 to include NRC/UIUC interactions that occurred after Release 02 of this TR.
RAI-4	Section 5.9: Note added to state that this TR does not include exemption requests.
RAI-5	Attachment 1; replaced rows for §50.34(a)(3)(i)&(ii) with §50.34(a)(3) "Applicable as is"
RAI-6 &	<p>Attachment 1 applicability determination changes:</p> <ul style="list-style-type: none"> §50.34(g): "3 Applicable as is"- This regulation subpart is also addressed through

Public Meeting Action	<p>§50.44(d)(1).</p> <ul style="list-style-type: none"> • §50.44(d): "3 Applicable as is" - Inserted a new row for §50.44(d), aligns with Kairos Hermes Test Reactor.
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EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) conducts its reactor licensing activities through regulatory requirements codified in Title 10 – Energy of the Code of Federal Regulations (10 CFR) supplemented by various types of guidance. Title 10 Part 50 – Domestic Licensing of Production and Utilization Facilities is the backbone of the regulatory framework for licensing nuclear facilities.

The University of Illinois Urbana-Champaign (UIUC) is proposing to construct a research reactor (also known as a non-power production or utilization facility (NPUF) using high temperature gas-cooled reactor (HTGR) technology. In particular, UIUC plans to build and operate Ultra Safe Nuclear Corporation's (USNC) Micro Modular Reactor® (MMR®) HTGR-based design. This topical report (TR) provides the determination of applicability of NRC regulations for licensing, construction, and operation of the MMR at UIUC.

The UIUC MMR deployment is an HTGR with its maximum power set at that permitted under a research reactor license. The MMR is planned to be licensed at UIUC as a Class 104(c) NPUF, in accordance with 10 CFR 50.21(c). Some regulations apply only to power reactors. Further, because the MMR does not utilize water moderation or cooling, NRC regulations that are specifically applicable only to water-cooled and/or moderated reactors (i.e., light-water reactors) are not relevant.

This TR provides a regulatory gap analysis that evaluates the applicability of NRC regulations to the UIUC MMR at a level of detail necessary to assess their relevance to the UIUC MMR. It identifies regulations that are applicable, that are not applicable based on entry conditions (e.g., type of reactor technology, qualification as an NPUF as opposed to a power reactor), that require a different approach (i.e., meet intent), or that may require an exemption.

UIUC is requesting NRC review and approval for the determinations of applicability/non-applicability of specific regulations identified in this TR as the licensing basis for the MMR at UIUC. Approval for exemptions will be requested and justified as part of future license application submittals.

CONTENTS

1.0	INTRODUCTION	10
1.1.	PURPOSE.....	10
1.2.	BACKGROUND	10
1.3.	REGULATORY EXPECTATIONS	11
1.4.	SCOPE	11
1.5.	NRC ACTION REQUESTED	12
2.0	MMR® TECHNOLOGY	13
2.1.	KEY DESIGN FEATURES FOR DETERMINING APPLICABILITY OF REGULATIONS	15
3.0	REGULATORY FOUNDATIONS	16
3.1.	APPLICABILITY OF EXISTING REGULATIONS TO NON-LWR TECHNOLOGIES	16
4.0	APPLICABILITY OF SPECIFIC REGULATIONS TO MMR TECHNOLOGY	19
4.1.	APPLICABILITY IDENTIFIED IN REGULATIONS VIA ENTRY CONDITIONS	20
4.2.	NRC DRAFT STAFF WHITE PAPER.....	22
4.2.1.	Topical Areas Potentially Requiring Exemptions for Non-LWRs	25
4.3.	KAUIOS POWER LLC	26
4.3.1.	NRC Response to Kairos Methodology	27
4.4.	OKLO POWER, LLC	28
4.5.	UIUC MMR REGULATORY RELEVANCE	28
4.6.	LICENSING ALTERNATIVES	29
4.7.	ADDRESSING NRC STAFF QUESTIONS	30
5.0	EXEMPTION PROCESS	31
5.1.	PROCESS FOR EXEMPTIONS FOR 10 CFR 50	31
5.1.1.	Exemption Process in Other Parts.....	31
5.2.	SUITABILITY OF AN EXEMPTION	31
5.3.	EVALUATIONS OF REGULATORY CONSIDERATIONS FOR NON-LWR TECHNOLOGIES	32
5.4.	EXCLUSION VS. EXEMPTION – ENTRY CONDITIONS OBIATE EXEMPTIONS	34
5.5.	NRC STAFF POSITIONS ON EXEMPTION REQUESTS	35
5.5.1.	Original September 2020 draft	35
5.5.2.	Revised July 2021 draft	36
5.5.3.	Interim Staff Guidance	37
5.6.	UIUC APPROACH.....	37
5.7.	REQUESTING AND JUSTIFYING EXEMPTIONS	39
5.8.	NRC REVIEW OF EXEMPTION AND RECOMMENDATIONS FOR NON-APPLICABILITY	40
5.9.	UIUC MMR EXEMPTION REQUESTS.....	40
6.0	SUMMARY OF PLANNED APPROACH	41
6.1.	EXPECTED EXEMPTIONS	41
6.1.1.	Security and Safeguards	41
7.0	REFERENCES	44

ABBREVIATIONS & ACRONYMS

This list contains the abbreviations and acronyms used in this document.

Abbreviation or Acronym	Definition
ACRS	Advisory Committee on Reactor Safeguards
ADS	automatic depressurization system
AEA	Atomic Energy Act of 1954, as amended
AEC	[U. S.] Atomic Energy Commission
AFWS	auxiliary feedwater system [in LWRs]
AGR	Advanced Gas Reactor [fuel test program]
AP1000	[Westinghouse] Advanced Passive 1000 plant
AR	advanced reactor
ATWS	anticipated transient without scram
BNL	Brookhaven National Laboratory
BWR	boiling water reactor
COL	Combined License [per 10 CFR 52]
COLA	Combined License Application [per 10 CFR 52]
CP	Construction Permit [per 10 CFR 50]
CPA	Construction Permit Application [per 10 CFR 50]
DANU	NRC Division of Advanced Reactors and Non-Power Production and Utilization Facilities
DOE	[U.S.] Department of Energy
DSRS	Design Specific Review Standard
ECCS	emergency core cooling system
EIS	environmental impact statement
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
EPZ	emergency planning zone
EQ	environmental qualification [of SSC for accident environmental conditions]
ESBWR	Economic Simplified Boiling Water Reactor
ESP	Early Site Permit [under 10 CFR 52]
FCM®	fully ceramic micro-encapsulated
FHR	[Kairos] fluoride [salt-cooled] high temperature Reactor
FSAR	Final Safety Analysis Report
GAO	Government Accountability Office
GDC	General Design Criteria (i.e., Appendix A of 10 CFR 50)
HALEU	high-assay low-enriched uranium (i.e., enriched 5% to 20% in U-235, exclusive)
HEU	highly enriched uranium (i.e., enriched to at least 20% U-235)
HTGR	high temperature gas-cooled reactor
IAW	in accordance with
IMC	[NRC] Inspection Manual Chapter
ISFSI	independent spent fuel storage facility
ISG	Interim Staff Guidance
ISI	in-service inspection

Abbreviation or Acronym	Definition
ITAAC	inspections, test, analyses, and acceptance criteria
KP	Kairos Power, LLC
LER	licensee event report
LEU	low-enriched uranium (i.e., enriched to 5% or less in u-235)
LEU+	low-enriched uranium plus [enriched in range from 5% to 10%]
LLEA	local law enforcement agency (i.e., the local police)
LOCA	loss of coolant accident
LWA	limited work authorization [under 10 CFR 50]
LWR	light-water reactor
MC	monte-carlo [type of analysis]
MHA	maximum hypothetical accident
MMR®	Micro Modular Reactor®
MW	megawatts
NEI	Nuclear Energy Institute
NEIMA	Nuclear Energy Innovation and Modernization Act [115-439 (01/14/2019)]
NFPA	National Fire Protection Association [issues National Fire Code]
NP	non-power
NPUF	non-power production or utilization facility
NRC	[U.S.] Nuclear Regulatory Commission
NUREG	nuclear regulatory document
OL	operating license [in accordance with 10 CFR 50]
OLA	operating license application
OMB	[U.S.] Office of Management and Budget
PDC	Principal Design Criteria
PORV	power-operated relief valve
PRA	probabilistic risk assessment
PSAR	Preliminary Safety Analysis Report
PWR	pressurized water reactor
QA	quality assurance
RAG	regulation applicability group
RAI	request for additional information [from NRC]
RCIC	reactor cooling isolation condenser
RCP	reactor coolant pump
RCPB	reactor coolant pressure boundary
RCS	reactor coolant system
RG	Regulatory Guide (also “Reg Guide”)
RTR	research and test reactor
SECY	[NRC staff paper informing or proposing an action item to the NRC Commission]
SME	subject matter expert
SMR	small modular reactor
SNM	special nuclear material
SRM	Staff Requirements Memorandum
SRP	Standard Review Plan
SSCs	structures, systems, and components

Abbreviation or Acronym	Definition
TBD	to be determined
TICAP	Technology Inclusive Content of Application Project
TID	Technical Information Document
TMI	Three Mile Island [plant]
TRISO	Tri-structural Iso-tropic
UCO	Uranium carbonate
USNC	Ultra Safe Nuclear Corporation (i.e., the reactor design vendor)
U.S.	United States

1.0 INTRODUCTION

A Micro Modular Reactor® (MMR®) is being developed by Ultra Safe Nuclear Corporation (USNC) with plans to be built and operated at the University of Illinois Urbana - Champaign (UIUC) as a Class 104 utilization facility in accordance with 10 CFR 50.21(c).

1.1. PURPOSE

The purpose of this topical report (TR) is to provide a gap analysis that evaluates the applicability of NRC regulations to the UIUC MMR at a level of detail necessary to assess their relevance and to establish the process for identifying exemptions to NRC regulations (Reference 1). The requested scope of NRC review and approval is identified in Section 1.5.

1.2. BACKGROUND

The MMR is a high temperature gas-cooled reactor (HTGR) limited to the research reactor power limit for the UIUC deployment. It uses an inert gas, helium, as the heat transfer fluid. The reactor will be fueled with High Assay Low-Enriched Uranium (HALEU) at an enrichment between 5% and 20% ²³⁵U in the form of tri-structural isotropic (TRISO) particles embedded in silicon carbide Fully Ceramic Micro-Encapsulated (FCM®) pellets that are stacked in columns in solid hexagonal graphite blocks. Plant life is set by its core operating life based on effective full power hours (average fission power time length of period producing power). The MMR is designed for passive safety response to design basis accidents and relies on functional containment as the primary means to limit release of radioactivity to the environment.

The UIUC MMR will be licensed under 10 CFR 50, and the construction permit application (CPA) targets submittal to the NRC in 2024. As a non-water, non-power reactor, the UIUC MMR does not match the underlying assumptions that form the basis for many NRC regulations. The Nuclear Energy Innovation and Modernization Act (NEIMA) directed the NRC to develop licensing strategies that include the use of TRs to improve the efficiency, timeliness, and cost-effectiveness of licensing reviews.

In Reference 3, the NRC discusses approaches to improving the timeliness and efficiency of advanced reactor licensing reviews through early interactions. A key action is submitting TRs for staff review and approval: principal design criteria (PDC), licensing basis events, safety-classification methodology, fuel qualification and testing plans, accident source term, etc. Preparation and submittal of documents on these matters is underway. In addition, Reference 3 suggests other interactions, including providing “a regulatory gap analysis report listing those 10 CFR 50 or 52 requirements for which the applicant plans to request an exemption or seek a case-specific order or rule of particular applicability.” Reference 3 notes that regulatory gap analysis for non-LWRs should consider the NRC staff draft white paper (Reference 4 and subsequent revisions) on relevance of regulations to non-LWRs.

1.3. REGULATORY EXPECTATIONS

The NRC is continuing to develop requirements and guidance for non-LWRs. The applicability of regulations in this TR is consistent with the current NRC framework for non-light-water, non-power reactors and provides reasonable assurance of adequate protection of public health and safety. UIUC will routinely monitor Federal Register Notices indicating changes to Title 10 Parts 1 through 199 by subscribing to FederalRegister.gov. Where proposed rulemaking could affect regulations applicable to the UIUC reactor, the applicability and impact of the rulemaking will be assessed through a process similar to that described in Table 5.1.

The process and results of this assessment are consistent with NRC action (Reference 5) on a similar effort by Kairos Power LLC.

The non-light-water MMR design in a non-power role is specifically excluded from a number of regulations.

The determination of relevance of regulations is based on the UIUC MMR meeting the following criteria that limit applicability of some regulations:

- Operation as a non-power Class 104(c) research reactor. Licensed power will not exceed the maximum allowable power for qualifying as a research reactor.
- Use of TRISO fuel particles in pellets formed of a FCM matrix and held in graphite blocks to provide functional containment.
- Core cooling using a primary heat transfer fluid, helium, that is single phase and chemically inert, with an accident analysis demonstrating fuel performance limits are met for a complete blow down.
- The nuclear plant is effectively buffered from external transients by an intermediate molten salt loop. The MMR at UIUC will be tied into the campus utility systems in the nearby Abbott Power Plant. However, the revenue from operation will not exceed the criteria of the Atomic Energy Act to qualify as a Class 104(c) non-power production or utilization facility (NPUF).

1.4. SCOPE

UIUC will be applying for a 10 CFR 50 construction permit (CP) and subsequent operating license (OL), using the guidance of the NUREG-1537 (Reference 6) standard review plan. This TR is part of pre-submittal activities to support NRC review of the CP and OL applications.

UIUC is the license applicant and owner/operator, with USNC as reactor designer/vendor/original equipment manufacturer and fuel supplier.

This TR considers regulations associated with preparing the CP and subsequent OL for a research reactor facility in accordance with 10 CFR 50. The facility will be licensed under the provisions of 10 CFR 50.21 as a Class 104(c) NPUF. The MMR is also a non-LWR. These characterizations limit applicability of some NRC regulations.

This TR focuses on relevance of regulations to the UIUC MMR. NRC guidance documents such as regulatory guides are not addressed, because exemptions are not required to deviate from them. Advance agreement on applicability of NRC regulations to the UIUC MMR CP and OL applications will allow the review to proceed in a more efficient and timely manner and is

consistent with guidance in Reference 3.

The UIUC preliminary safety analysis report (PSAR) and final safety analysis report (FSAR) will address guidance in accordance with the research reactor standard review plan (Reference 6), as is outlined in Reference 7.

UIUC is not following a combined construction and operating licensing application (COLA) approach for the MMR. Therefore, regulations in 10 CFR 52 are not applicable and will not be individually dispositioned in this TR.

The safety classification of plant structures, systems, and components (SSCs) will be established on a deterministic basis. Therefore, considerations associated with NEI 18-04 and the Technology Inclusive Content of Application Project (TICAP) are not discussed.

1.5. NRC ACTION REQUESTED

UIUC requests NRC review (Reference 2) and approval of this Topical Report to determine acceptability of specific regulations identified in this TR as the licensing basis for the MMR at UIUC, listed in Attachment 1, "Assignment of NRC Regulations to UIUC-MMR Regulation Applicability Groups".

Note: The methodology developed and employed for determining the applicability of regulations for the UIUC research reactor in this TR is provided for informational purposes only.

2.0 MMR® TECHNOLOGY

The proposed MMR at UIUC involves technology and safety capabilities considerably different from LWR technology that is the focus of many regulations. For example, the MMR does not require an active or passive emergency core cooling system (ECCS) to rapidly replenish primary coolant to recover the fuel in the event of a rupture of the primary pressure boundary. Large safety margins are provided by the design:

- Fuel is comprised of tri-structural isotropic (TRISO) particles, which provide a highly effective fission product retention capability. In accordance with a TR on performance of TRISO fuel (Reference 8), the NRC issued a safety evaluation report (Reference 9) with some limitations and conditions that are considered in the MMR design. The superior fission product retention capability of TRISO fuel particles enables the concept of “functional containment” in which these particles serve as the principal containment barrier when operated within the range of experimental qualification. Functional containment is recognized in Regulatory Guide 1.232 (Reference 10), which provides Principal Design Criteria (PDC) for HTGR use in lieu of 10 CFR 50 Appendix A General Design Criteria (GDC). Note RG 1.232 scope is limited to power reactors, consistent with the GDC; however, footnote 4 states “the design criteria described in this RG may be applied, as appropriate, to non-light-water non-power reactors.”
- A unique feature of the MMR fuel is that the TRISO particles are encased in a Fully Ceramic Micro-encapsulated® (FCM®) pellet of silicon carbide that provides an additional layer of defense-in-depth for the retention of fission products.
- Low power density of active fuel slows fuel heat up during loss of cooling events.
- Low thermal power results in a small inventory available for release of the most limiting short-lived fission products for public safety, such as I-131 and Kr-85. The increased inventory of long-lived fission products associated with a long core life is addressed.
- The low power rating also reduces the decay heat that must be removed in postulated accident, simplifying passive decay heat removal.
- Heat transfer fluid used for core cooling during normal operation is an inert, chemically stable, gas (helium).
- Safety-related core cooling is passive and capable of maintaining fuel and component temperatures below limits with no helium, electrical power, or operator action.
- Secondary heat transfer is by a molten salt loop that effectively isolates the reactor from transients in the adjacent plant power conversion system.
- The reactor is below ground. Although it does not have nor need a leak-tested containment building, it is surrounded by a below ground concrete structure (the citadel) that serves as a barrier to release of radioactivity to the environment and provides protection against external hazards.

This report does not provide a detailed description of MMR safety features nor an assessment of the ability to meet the NRC requirements for protection of the health and safety of the public. The PSAR and ultimately the FSAR will contain the safety basis for the MMR. Table 2-1 is a high-level summary of key features of the MMR design and the significance of differences from LWRs to assist in understanding the justifications for non-applicability of certain regulations discussed later.

Table 2-1. MMR Key Features and Differences from Operating LWRs

Feature	MMR	LWR	Remarks
Operating power level	Power limited to research reactor maximum power (currently 10 MW)	3000 to 4400 MW(t) (AP1000 3415 MW(t))	Full UIUC MMR power is less than decay heat of large LWR more than 24 hours after shutdown; short-lived fission product inventory is small
Heat transfer fluid	Helium – inert gas; single phase under all conditions; low stored energy	Water – also serves as moderator; scrubs fission products; high stored energy; undergoes phase change that causes high pressure and temperature in surrounding structure	Water coolant causes corrosion, and blowdown can damage safety systems by impingement, pressure, moisture, and temperature
Containment	Functional: TRISO integrity at high temperatures, with supplemental passive barriers for defense-in-depth, continuously confirmed by radiological monitoring while operating	Large containment building: subject to high pressure and temperature; many penetrations requiring active isolation, periodic leak testing, and maintenance	Functional containment is a barrier or set of barriers that effectively limit physical transport of radioactive material to the environment and serve as basis for the revised PDC in RG 1.232
Confinement	Citadel features	N/A	Below ground vault provides fission product barrier, shielding, protection from external hazards
Safety-related ac power systems	None	Class 1E ac distribution and emergency diesel generators	MMR safety is provided by passive systems
Refueling frequency	Infrequent (based on core U-235 loading and low operating power)	Every 1.5 to 2 years	Reduces used fuel handling and storage risk
Fuel form	Uranium oxycarbide (UCO) TRISO particles encased in FCM pellets in a hexagonal graphite fuel blocks	Uranium dioxide pellets encased in zirconium alloy tubes	Negligible fission product release from MMR during operation or accidents
Fuel (²³⁵ U) enrichment	High assay LEU (HALEU) < 19.75% ²³⁵ U	LEU < 5% ²³⁵ U (industry is pursuing LWR fuel up to 10% ²³⁵ U)	Both are low-enriched uranium; MMR enrichment provides for long core life
Fuel damage temperature	> 3272°F (1800°C)	2200°F (1204°C)	Zirconium-water reactions start at about 1800°F in LWRs
Emergency replenishment of coolant	None; fuel limits met for unmitigated primary system blowdown	Emergency Core Cooling System (ECCS) needed	Must quickly recover LWR fuel with water if loss of coolant occurs
Hydrogen management	External/internal flooding might release hydrogen (graphite-water reaction)	Zirconium-water reaction produces hydrogen if clad exceeds 2200°F	Acceptance criteria limit mass of LWR fuel clad reacted
Primary system corrosion mechanisms	While helium itself is non-corrosive, contaminants must be controlled to low levels to avoid degradation of graphite and other materials	Various types of stress corrosion cracking; boric acid corrosion (PWRs)	Helium is inert whereas hot water is corrosive unless water chemistry is carefully controlled

2.1. KEY DESIGN FEATURES FOR DETERMINING APPLICABILITY OF REGULATIONS

In the NRC Staff Safety Evaluation Report (SER) for the Kairos regulatory gap analysis (Reference 5), the NRC staff identified key design features that served as justification for differences from LWR requirements.

- Chemically stable coolant – the NRC staff noted that verification of molten salt coolant performance will be necessary. The MMR will use an inert gas, helium, as its heat transfer medium. Helium has previously been used in licensed HTGRs in the U.S. and elsewhere and is chemically stable.
- TRISO fuel particles and fuel pebbles – Reference 5 notes the need to confirm performance criteria are consistent with the methodology described in SECY-18-0096, “Functional Containment Performance Criteria for Non-Light-Water-Reactors” (Reference 11). The NRC notes that this includes identifying event sequences and the associated SSCs. Functional containment performance criteria include not only radionuclide retention but also reactivity control and decay heat removal. These aspects will be addressed for the UIUC MMR in subsequent pre-submittal reports and in the PSAR. Note also that the MMR holds its TRISO fuel in FCM compacts in non-moving graphite blocks, eliminating concerns with mechanical wear and variable burnup of pellets but requiring confirmation of FCM capability.
- Intermediate coolant loop – the secondary coolant should be demonstrated as chemically compatible with the reactor coolant. In the MMR design, the inert helium eliminates the possibility of primary/secondary coolant chemical interactions. Although the MMR does not rely on the molten salt secondary coolant for safety-related functionality, it does provide a means to isolate the reactor from transients external to the nuclear plant. Also, the molten salt will include activity from neutron irradiation that must be considered in radiological evaluations (e.g., personnel dose).
- Near atmospheric pressure of reactor coolant system – the NRC staff states that the low-pressure molten salt reactor coolant system in the Kairos design results in a “fundamentally different risk profile,” compared to LWRs. Although the MMR primary system is pressurized, the operating pressure is considerably below that in LWRs, the helium coolant is single phase and contains a small amount of stored energy, and blowdown of the reactor coolant system will not challenge the functionality of safety-related SSCs or functional containment.
- Maintain coverage of fuel with reactor coolant – although this is necessary for consistency with design basis event assumptions for many reactor technologies (e.g., LWR, molten salt), it is not meaningful for an HTGR nor necessary for the MMR, which is analyzed for adequacy of safety-related core cooling with the condition of the helium heat transfer system vented.

3.0 REGULATORY FOUNDATIONS

The Atomic Energy Act of 1954 (P.L. 83–703), as amended, provides the statutory authority for the NRC to regulate nuclear facilities. The NRC conducts its reactor licensing activities primarily through regulatory requirements found in Title 10 – Energy of the Code of Federal Regulations (10 CFR) Parts 50 and 52 supplemented by various types of guidance. Administrative and detailed technical provisions are commingled and distributed throughout 10 CFR Parts 1 to 199. Most of these 10 CFR Parts are non-technical or non-utilization facility regulations and, therefore, considered of little or no relevance to designing new reactors. Requirements that may be technology specific are mostly in 10 CFR 20, 50, 51, 52, 71, 72, 73, and 100. The applicability of many items in these Parts of Title 10 is defined within the individual regulations. Even where this is not the case, most of these Parts provide a process for requesting exemptions under specific circumstances with suitable justification.

The 10 CFR 50 approach to licensing a nuclear reactor plant is a well-established two-step process, having been used to license the current US fleet of nuclear reactors within both Class 103 and 104 licenses. The two-part process involves obtaining a CP to build the nuclear plant followed by approval of an OL. All currently operating reactors in the U.S. were licensed in accordance with this approach. Subsequently, the 10 CFR 52 combined operating license (COL) application alternative was issued in 1989 to reduce the potential to delay operation of a construction-complete plant, i.e., build and operate what was licensed. Experience with Part 52 has shown that considerable effort and potential for delay may occur if the application is submitted before detailed design is complete. The UIUC MMR application will use the Part 50 licensing pathway, and Part 52 regulations are not applicable to the project.

3.1. APPLICABILITY OF EXISTING REGULATIONS TO NON-LWR TECHNOLOGIES

The NRC, and its predecessor agency the U.S. Atomic Energy Commission (AEC), previously licensed non-LWRs (i.e., Peach Bottom Unit 1, Fort St. Vrain, Fermi 1). With these non-LWRs in operation (Fort St. Vrain was last to shut down in 1989), restricting applicability of some regulations specific to LWRs was informed by expert knowledge gained in reviewing those non-LWR designs. Therefore, the limitations of applicability to LWRs were actually exercised. Since that time, Part 50 has been continuously refined to address LWR reactor designs, including limited generic content that can be extended to non-LWR designs such as the MMR. However, developing regulations for non-LWRs has only recently become a priority.

The means of distinguishing relevance of specific regulations to specific reactor types has been entry conditions limiting applicability in recognition of technology differences. As noted in SECY-18-0096 (Reference 11):

“The NRC’s existing regulations and guidance for nuclear reactors were primarily developed for LWRs and the specific events and phenomena related to zirconium clad fuel and water coolant... Non-LWR technologies have operating conditions, coolants, and fuel forms that differ from LWRs. These differences may allow or possibly require different approaches to fulfilling the safety function of limiting the release of radioactive materials.”

Further, NRC regulations have been refined repeatedly for over half a century to define the attributes of a safe design for pressurized and boiling water reactors, which rely on similar safety features. Many of these specializations are explicitly identified for limited applicability (e.g., 10 CFR 50.46 *“Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors”*). However, in other instances, the water-focused nature of requirements is obscure (e.g., 10 CFR 50 Appendix A criteria for containment) or regulations include an unintended LWR bias in that they assume or stipulate characteristics or features that are unnecessary or unsuitable for other reactor types. A few examples are:

Loss of Coolant Accident (LOCA). Many regulations are tied to protection against LOCAs. In an LWR, a LOCA begins with a rupture of the reactor coolant primary pressure boundary (RCPB). Coolant potentially is lost to the point that the fuel clad breaches because it is no longer cooled by water and the fuel overheats and releases fission products. With the rupture discharging a large amount of mass and energy into it, the containment structure must be designed specifically to limit release of radioactivity to the environment during the sustained period that high temperature and pressure persists even after the LOCA blowdown subsides.

The MMR may also suffer a rupture of the RCPB, but the FCM fuel design limits release of radioactivity very effectively: the fuel itself is the primary containment barrier (Functional Containment) that will meet radiological dose limits without crediting any other barriers, such as confinement provided by the Citadel Building located below grade, for defense in depth. Additionally, the pressure created by blowing down into the reactor cavity is relieved quickly by normal leakage, removing the driving force to push radioactivity into the environment. An HTGR is susceptible to some different events such as air ingress into the core in a pressure boundary rupture scenario, but no rapid replenishment of coolant, safety-related ac power, or restoration of flow is necessary to maintain fuel integrity. Thus, most regulations originating out of LWR LOCA scenarios are not relevant for an HTGR.

Having recognized the need to address non-LWR safety in Parts 50, 52, and other applicable regulations, the NRC, with stakeholder input and direction from Congress, has been making strides toward introducing technology neutral requirements and guidelines that either replace or augment the existing regulatory requirements for non-LWR designs. This is still a work in progress: the NRC has issued some guidance documents (e.g., Regulatory Guide 1.232, *“Guidance for Developing Principal Design Criteria for Non-Light Water Reactors”*) and is preparing a new set of regulations for non-LWRs, which is expected to be issued as 10 CFR 53. However, the timing of the new Part 53 does not support the schedule for UIUC licensing. The NRC staff has prepared a number of draft guidance documents; these have been referenced by others in TRs and other pre-engagement submittals. This draft documentation and NRC’s discussion of future guidance are considered in establishing the approach discussed in this TR.

10 CFR 50.34(a)(3)(i) states that Appendix A, *“General Design Criteria for Nuclear Power Plants,”* establishes minimum requirements for the principal design criteria (PDC) for water-cooled nuclear power plants similar in design and location to plants for which CPs have

previously been issued and provides guidance to applicants for CPs in establishing PDC for other types of nuclear power units. Section C of RG 1.232 states;

“This RG provides guidance to reactor designers, applicants, and licensees of non-LWR designs for developing PDC. Since the GDC in 10 CFR 50 Appendix A are not regulatory requirements for non-LWR designs but provide guidance in establishing the PDC for non-LWR designs, non-LWR applicants would not need to request an exemption from the GDC in 10 CFR Part 50 when proposing PDC for a specific design.”

As previously noted, footnote 4 of RG 1.232 states that its guidance may be used by non-light-water, non-power reactors. As shown in Attachment 1, the MMR to be constructed at UIUC will address PDCs without the need for an exemption, as specified in RG 1.232. The UIUC MMR will meet the intent of the MHTGR PDC in the regulatory guide.

4.0 APPLICABILITY OF SPECIFIC REGULATIONS TO MMR TECHNOLOGY

Although regulation of non-LWRs has been discussed extensively since the 1990s, the NRC has thus far issued or endorsed only limited official guidance interpreting relevance of specific, existing regulations, or codified regulations that would apply to non-LWRs. Existing regulations specifically stating applicability to LWR structures, systems and components are appropriately limited to LWR technologies. The regulations contain many items that either are not or only partially relevant to non-LWR designs such as the HTGR-based MMR design.

Regulation Applicability Groups (RAGs) have been defined (Table 4-1) to categorize the relevance of specific regulations in accordance with entry conditions or other plain language direction. This section describes the process for assignment of current regulations to a RAG, and the basis for placing a regulation in a specific group. Requirements in 10 CFR Parts 1 through 199 were evaluated. Part 50 contains the majority of the regulations requiring evaluation for the UIUC MMR, including subparts, as necessary. Associated regulatory guidance documents are discussed only when appropriate to support the basis for determining applicability.

Table 4-1. Regulation Applicability Groups for MMR at UIUC

Group	Basis
1 N/A	HTGR/MMR technology differs in fundamental ways from that of LWRs. The capability, system, or feature is not required. Regulations in this group are not applicable because they have entry criteria (see Section 4.1) pertaining to: <ul style="list-style-type: none"> Facility type: those that are not a utilization facility (i.e., not a reactor) Reactor type: specifically applicable to a LWR (PWR, BWR) or D₂O Specific time frame: applications submitted prior to 2023 Specific license application: those that reference a specific project Application type: other than Part 50 construction permit and OL
2 N/A to NPUF	NPUFs do not need to meet regulations that have entry conditions pertaining to a “nuclear power plant,” “power reactor,” or similar. Based upon UIUC qualifying for a Class 104(c) license, which is a non-power production or utilization facility (NPUF), the power reactor regulations are not applicable.
3 Applicable as is	Regulation applies, although there may be sub-paragraphs that have their own specific entry conditions as noted.
3A Modified/partial	Regulation applies, with some specific limitations or modifications, which are not considered to be significant deviations that require an exemption, or where portions down to the paragraph level may not be applicable and would be so noted as N/A in the subsequent row(s).
3B Meets intent	Regulation applies and the underlying safety basis is relevant, but the means of implementation are subject to interpretation. The UIUC approach is considered to meet the intent of the regulation and not require an exemption. An alternative approach would be more appropriate for the MMR design to meet the regulation. This will be provided in the PSAR and FSAR.
3C Administrative	Applies but does not affect design or technical requirements.
3D NRC, not applicant	Regulation pertains to NRC activities not relevant to an applicant or licensee.
4 Request exemption	UIUC may deviate from the regulation. UIUC may request an exemption.

The process for assigning regulations (or subsections thereof) to the MMR RAGs defined in Table 4-1 takes into consideration available guidance and precedents. The presence of entry conditions is the primary means to determine relevance, such as regulations labeled or otherwise delineated as applicable to specific reactor types, license types, etc. (see Table 4- 2). As the completeness of the regulations has not been confirmed through past use for a high temperature gas-cooled research reactor, implementing all the exclusions could leave gaps. UIUC has carefully assessed non-applicable regulations and their intent to ensure the regulatory basis described in the TR leaves no gaps. For regulations having entry conditions not met by the UIUC MMR, it is classified as N/A in accordance with groups 1, 2 or 3D of Table 4-2. For those regulations not excluded by an entry condition, the regulation is assessed to determine if it is applicable as-is, only partially applicable or otherwise needs modification, applicable subject to interpretation but meets the intent, or administrative; or otherwise should be considered for exemption.

Where possible, an entire Part or paragraph is evaluated as a unit. However, in many cases and especially in Part 50, entry conditions exist below the paragraph level. For those, a single regulation is assessed as far down the CFR hierarchy as necessary.

Upon completion of preliminary grouping in accordance with the entry conditions in Table 4-2, the results were compared to other sources of potentially relevant information, such as:

1. NRC staff draft white paper – “Analysis of Applicability of NRC Regulations for Non-Light Water Reactors,” dated September 2020 (Reference 4) and updated in July 2021 (Reference 12).
2. Kairos Power reactor “Regulatory Analysis” TR (Reference 13) – the methodology was generally found acceptable by the NRC (Reference 5).
3. NRC letter dated November 2020 identifying applicability of a limited set of regulations to the proposed Aurora microreactor design (Reference 14).
4. As part of preparation of Release 02 of this TR, these references were again considered for those regulatory areas questioned by the NRC staff reviewers. In some cases, this resulted in minor revisions.

If the preliminary grouping differed from one of these references, the UIUC MMR group assignment was reassessed. This resulted in a RAG change in some cases, but the groupings in the cited references were not viewed as definitive, given different reactor technology or licensing conditions.

Also, publicly available information from the Kairos Power and Oklo Power projects was used to assess the general logic and completeness of this TR in the absence of established regulatory precedent for new design non-LWRs.

4.1. APPLICABILITY IDENTIFIED IN REGULATIONS VIA ENTRY CONDITIONS

Some regulations contain criteria called “*entry conditions*” by the NRC that specify the population of NRC-regulated activities to which they apply. Entry conditions for regulations are based on a variety of distinctions, as summarized in Table 4-2.

There are many instances in 10 CFR 50 where a paragraph or underlying sub-paragraph of a regulation identifies limited applicability in terms of these various entry conditions, such as:

- {a} 50.61(2) defines Pressurized Thermal Shock Event as "an event or transient in pressurized water reactors (PWRs)...".
- {b} 50.34(f) states each applicant for a light-water-reactor construction permit or.... "Specific items of these Three Mile Island accident actions are further restricted, such as 50.34(f)(1)(ii) and (iv) are labeled "Applicable to PWR's only" whereas 50.34(f)(1)(v) through (xi) are marked as "Applicable to BWR's only." The ESBWR Design Control Document (Reference 15) identifies these criteria in Tier 2 Table 1A-1.
- {c} 50.46(a)(1)(i) starts "Each boiling or pressurized light-water nuclear power reactor fueled with uranium oxide pellets..."
- {d} 50.54(o) stipulates "Primary containments for water cooled power reactors... shall be subject to the requirements set forth in appendix J to this part." Additionally, Appendix J is titled "Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors" and its Introduction paragraph states its purpose is "...tests of the leak-tight integrity of the primary reactor containment, and systems and components which penetrate containment of water-cooled power reactors...."
- {e} 50.36(a)(2) stipulates "(2) Each applicant for a design certification or manufacturing license under part 52 of this chapter shall include...." This type of limitation is used throughout 10 CFR 50 to identify which type of license requires specific actions.
- {f} Appendix I is titled, in part "...to Meet the Criterion 'As Low as is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents." There are over 20 instances where the appendix specifies use for "light-water-cooled" reactors. However, there is considerable variation in the exact wording.
- {g} 50.55a(g)(6)(ii)(D) *Augmented ISI Requirements Reactor vessel head inspections—(1) Implementation*. Holders of operating licenses or combined licenses for pressurized-water reactors as of or after June 3, 2020, shall implement the requirements of..."

For above examples {a}, {b}, {e}, and {g}, the NRC does not require an application excluded by the entry condition to request an exemption from each (e.g., the design certification application for the Economic Simplified Boiling Water Reactor (ESBWR) did not need an exemption from those items in {b} which applied only to PWRs but did for 50.34(f)(2)(iv) which was not restricted to PWRs (see Reference 16 and Section 1.10 of Reference 15). It would be, therefore, inconsistent with regulatory precedent for the NRC to expect applications for non-LWRs to request an exemption from a requirement that is clearly not relevant and explicitly identified as limited to LWRs, such as examples {c}, {d}, and {f}.

Some regulations may appear to define limited applicability in their titles. Table 5.1 provides the process that includes reviewing subparts to the regulations and the associated FRNs.

For example, Appendix J to Part 50 is titled "Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors." This is more obvious but consistent with the entry condition in the 50.54(o) which begins "Primary reactor containments for water cooled power reactors ..."

Table 4-2. Entry Conditions for Regulation Applicability

Entry Condition Type	Applicable Conditions	Conditions Not Applicable to UIUC
Utilization facility (i.e., reactor)	Utilization facility	Production facility, byproduct material licensee
Class 104 10 CFR 50.21c	Non-power utilization facility Non-power reactor Research reactor	Stationary power reactor Commercial reactor Power reactor Test reactor Class 103 licensee
License pathway	<u>Part 50</u> Construction permit applicant OL applicant	<u>Part 52</u> Design certification Standard design approval Manufacturing license Combined operating license
Reactor technology	Gas-cooled reactor (HTGR)	Water-cooled reactor Pressurized water reactor (PWR) Boiling water reactor (BWR) Metal clad fuel Medical or isotope reactor
Timing of application	Construction permit application submittal in 2024	Submitted application prior to 2024
Number of units on site	Single unit	Multi-unit site

Applying these entry conditions to determine the need to comply with specific regulations is an established, proven process. Changes in regulations implemented by rulemaking completed within six months of docketing of the CPA will be addressed in accordance with the process described herein.

4.2. NRC DRAFT STAFF WHITE PAPER

During late 2020 and the first part of 2021, the NRC staff issued a draft white paper (Reference 4) providing a detailed breakdown of applicability of existing regulations to non-LWRs, held meetings, and revised the white paper (Reference 12), to facilitate discussion with stakeholders. The document was marked draft with a disclaimer on its cover page that its contents were subject to change and should not be interpreted as agency positions. Its appendix describes a process to use the NRC categorization of applicability of regulations and how to determine the need to request an exemption (the latter is discussed in the next section of this report). This draft appendix starts by stating that a regulation found to not be applicable to any non-LWR need not be addressed in a license application:

“There is no expectation that applicants address regulations that are not applicable to any non-LWR on their face.”

The NRC acknowledged that a wider population of regulations than listed might be found to not be applicable to certain types of reactors but that the staff was not ready to do so. The NRC subsequently included it as Appendix D of a draft interim staff guidance (ISG) document (Reference 17).

The NRC staff white paper grouped regulations into six categories and provided a table for each category listing the regulations and denoting whether each is applicable to a non-LWR power reactor. The categories are listed below, with annotations regarding their relevance to the

UIUC MMR in italics.

1. Part 50 regulations to be considered by non-LWR designers (i.e., applicable). *These should be considered for the MMR, but may not be applicable to research reactors.*
2. Select Part 52, Subparts B through D, expected by the NRC staff to be used for most non-LWRs (i.e., applicable). *As the UIUC MMR is being licensed under Part 50, these are not relevant.*
3. Regulations from parts of Title 10, other than Parts 50 and 52, that may apply to non-LWRs at some stage in the licensing process (i.e., potentially applicable). *These should be considered for the MMR, but may not be applicable to research reactors.*
4. Requirements under 10 CFR 50.34(f) (i.e., Three Mile Island (TMI) accident action items) that are only applicable for Part 52 applications because Part 50 has entry conditions that restrict applicability. Applicants are required to demonstrate compliance with the technically relevant TMI items. The NRC notes that the term “technically relevant” allows for a greater degree of flexibility in meeting the regulation. If a sound case can be made that the requirement in question is not technically relevant to a design, the requirement is satisfied without a need for an exemption. The tables in the draft white paper provide generic applicability determinations for non-LWRs, with entry conditions for technical relevancy listed for some items. If the entry conditions are not met, then the regulations are considered not applicable. The 10 CFR 50.34(f) citations not listed are considered not applicable. *Although unlikely to be relevant, these should be considered for the MMR, but may not be applicable to research reactors.*
5. Regulations associated with fission product release, criticality, and the RCPB for which the underlying regulatory basis applies generically, but where regulations contain language that is specific to LWRs. The safety basis of various advanced reactor designs varies widely enough that a generic resolution for each is not currently practical. The NRC states that non-LWR applicants are expected to request exemptions from these regulations, but the precise nature of a requested exemption will depend on the specific technology and how other regulations are being met. *These should be considered for the MMR, but may not be applicable to research reactors.*
6. Regulations in Parts 50 and 52 that apply to all power reactors but reference a 10 CFR 50 regulation that refers specifically to LWRs (i.e., likely not applicable). Because these regulations apply to all power reactors, non-LWR power reactor applicants under 10 CFR Parts 50 or 52 would likely request exemptions from these requirements or could choose to demonstrate compliance. If the application contains the design information already required by NRC regulations to be included in the application, such information should form sufficient bases for these exemptions. Applicants do not need to include the exemption information (e.g., justification of need, scope, evaluation against exemption criteria) of 10 CFR 50.12 but would, instead, include a statement requesting an exemption because the design is a non-LWR and, therefore, not subject to the referenced Part 50 regulations. *These are not applicable for the MMR, a research reactor, and do not require an exemption because of the power reactor entry condition.*

NRC provided a diagram of the process proposed in the draft white paper (repeated here as Figure 4-1) but annotated in orange with details of the UIUC MMR process. The entry condition screening is similar to the NRC’s process, with exclusion expanded to include entry conditions pertaining to power reactors.

The item with orange ✘ is not relevant because UIUC and USNC provide the exclusion and exemption justifications.

Entry conditions that exclude applicability

- Reactor use: not a research reactor (i.e., power)
- Facility type: those that are not a utilization facility (i.e., not a reactor)
- Reactor type: specifically applicable to a water primary system (e.g., LWR, PWR, BWR)
- Specific time frame: applications submitted prior to 2023
- Specific license application: those that reference a specific project

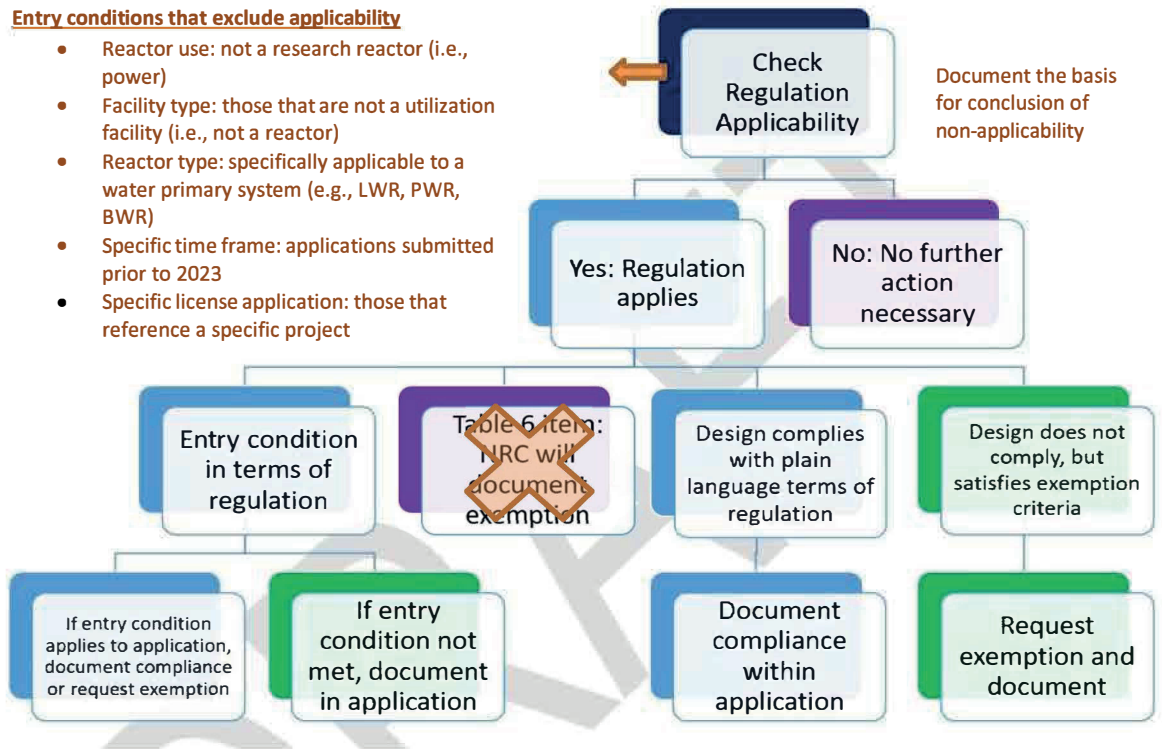


Figure 4-11. Draft NRC White Paper Logic Diagram for Non-LWR Regulation Applicability (Reference 17)

4.2.1. Topical Areas Potentially Requiring Exemptions for Non-LWRs

Table 5 of the draft NRC staff white paper discusses the need for design-specific consideration of three areas: fission product release, criticality, and the RCPB. For each, the NRC states the underlying regulatory basis applies to all reactor technologies, but the regulations contain language that is specific to LWR designs. For the UIUC MMR, each of these is also subject to evaluation of non-power reactor applicability:

1. Fission product release – 10 CFR 50.34(a)(1)(ii)(D): As 50.34(a)(1) states stationary power reactors should comply with paragraph (a)(1)(ii), this regulation is excluded because the UIUC MMR is a non-power reactor.
2. Criticality monitoring – Requirements in 50.68 and 70.24 are focused on safety of fuel handling outside the reactor vessel (i.e., unshielded). 10 CFR 50.68 includes entry conditions that are specific to nuclear power reactors. However, the requirements in 10 CFR 70.24 are applicable to the UIUC research reactor. 10 CFR 70.24(d) states that 70.24(a) to (c) do not apply if the power reactor licensee complies with 10 CFR 50.68. UIUC is considering an exemption from 10 CFR 70.24 or 10 CFR 50.68 to allow use of fuel above 5% enrichment without implementing criticality accident requirements. Therefore, the determination was made in the TR that an exemption from these requirements (i.e., Group 4) may be needed by the UIUC research reactor. Safety of fuel handling outside the reactor during initial fuel loading and refueling will be shown acceptable without a permanently installed criticality accident monitoring system. The NRC staff white paper states that “In the absence of an exemption, a non-LWR application will be required to describe criticality monitoring required by 10 CFR 70.24.” As the UIUC MMR will have fuel enriched above the five percent limit in 50.68(b)(7) and will not require water for moderation, an exemption is considered to be needed. Justification to show criticality is prevented and monitoring is not required will be provided as part of the CPA.
3. RCPB (10 CFR 50.2, 50.36(c)(2)(ii), 50.49(b), 50.65, 10 CFR 50 Appendix S):
 - a. 50.2 - *Reactor coolant pressure boundary* is defined as all those pressure-containing components of “boiling and pressurized water-cooled nuclear power reactors.” The UIUC MMR is a non-power HTGR, making the definition not applicable on two grounds. However, RG 1.232 redefines GDC 14 *Reactor Coolant Pressure Boundary* as the *Reactor Helium Pressure Boundary*. RG 1.232 may be used by non-light-water non-power reactors and states “non-LWR applicants would not need to request an exemption from the GDC in 10 CFR Part 50 when proposing PDC for a specific design. UIUC would also not need an exemption from the GDC, as they are identified as applicable to nuclear power plants.

In addition, the change from reactor coolant to reactor helium pressure boundary also affects the definition of *basic component* in both 50.2 and 21.3. In both places, the applicability of *basic component* is stipulated as “when applied to nuclear power plants.” Therefore, although RG 1.232

replaces the reactor coolant pressure boundary criteria with those for the reactor helium pressure boundary, the UIUC research reactor may differ from the direction in the regulatory guide. As this is a deviation from a regulatory guide not a regulation, the technical justification for any such differences will be provided but no exemption should need to be requested.

- b. 50.36(c)(2)(ii) – although the MMR safety criterion to control release of radioactivity is accomplished by functional containment, maintaining integrity of the helium pressure boundary is appropriate as a defense in depth to reduce occurrence of events potentially leading to a design basis transient. The UIUC MMR will meet the intent of this regulation.
- c. 50.49(b) – this paragraph requires environmental qualification of safety-related electrical equipment that is relied on to ensure the integrity of the RCPB. The title of 50.49 has an entry condition limiting it to nuclear power plants.
- d. 50.65 – this paragraph has an entry condition in its title limiting it to nuclear power reactors.
- e. 10 CFR 50 Appendix S – this appendix has an entry condition in its title limiting it to power reactors.

4.3. KAIROS POWER LLC

As part of their pre-application engagement, Kairos Power LLC submitted a TR in January 2019 to identify the regulatory requirements applicable to the Kairos Power Fluoride Salt-Cooled High Temperature Reactor (KP-FHR). Subsequently, Kairos decided to first license and build a scaled version of KP-FHR as a test reactor (Hermes) rated at 35 MW(t), according to other documentation. Revision 4 of the TR (Reference 13 considers the latest NRC draft staff guidance at the time including the above-described white paper, reflects several iterations of discussions and RAIs with the NRC staff, and identifies regulation applicability based on screening for a non-power/test reactor with some similar features (non-LWR with TRISO fuel and functional containment).

The Kairos TR categorizes regulation applicability as shown in Reference 13 to determine if they are applicable to both the HERMES test reactor and the KP-FHR power reactor, to only the KP-FHR power reactor, or not at all.

The Kairos TR considered the full set of NRC regulations in 10 CFR Parts 1 through 199 and used Regulatory Guides, Standard Review Plans, Interim Staff Guidance, and generic communications to interpret them. The report identifies regulations that apply, do not apply, do not apply but are relevant, or require an exemption. Kairos notes that although some regulations do not literally apply, the intent is considered relevant. Kairos Power sought NRC approval to apply the TR for future applications under Part 50 or Part 52.

This TR uses an approach like that of Kairos to arrive at similar conclusions regarding applicability of specific regulations, allowing for technology differences. However, the Hermes test reactor is subject to some different regulations and guidance than the UIUC MMR research

reactor (e.g., accident radiation dose limits of Part 100 vs. Part 20).

4.3.1. NRC Response to Kairos Methodology

In Reference 5, the NRC staff concludes that the Kairos methodology is acceptable for determining applicable regulatory requirements and that identifying regulations as applicable, not applicable, or requiring an exemption is appropriate. However, the other distinctions regarding administrative, process, design, etc. (i.e., were not assessed, as the assignments “do not alter regulatory requirements).”

The NRC concluded that (except for 10 CFR 50.46 and 46c applicability to a test reactor) the regulations designated as “exemption” may apply (in whole or in part) to the licensing of the Kairos design. Therefore, the NRC declined to act on exemption requests, stating

“Accordingly, this SE does not reach any conclusion as to the acceptability or viability of any exemption request. The evaluation of whether an exemption should be granted would occur after the submittal of a specific exemption request and would be documented in the SE associated with a future licensing submittal.”

“Although the NRC staff does not reach a conclusion regarding the appropriateness of all screening criteria, the NRC staff generally finds that the methodology described in the TR is a detailed approach and is acceptable to identify the design and licensing requirements applicable to the KP-FHR.”

The NRC Safety Evaluation provides some generic feedback on the methodology used by Kairos:

- Kairos correctly categorized the applicability of the regulations listed in the appendices for a power or test reactor.
- Kairos’ determination “largely conforms with expected applicability of regulations for a generic non-LWR design, as described in the NRC staff draft white paper on that topic” (Reference 12).
- Applications must demonstrate compliance with regulations designated as applicable.
- Those regulations designated as inapplicable need not be met and no information related to these regulations is required in a future application that references the TR, subject to limitations and conditions identified.
- Using knowledge of general design characteristics of the Kairos design submitted as part of pre-application activities, the NRC staff concluded that information was sufficient to distinguish the Kairos design from a LWR design, confirming that requirements applicable to LWRs only do not apply to the proposed Kairos reactor.
- Because inaccuracies were found in some justifications, the NRC staff does not approve the stated bases for the applicability determination, even though the inaccuracies did not invalidate the applicability determination.

- Table entries in the TR sometimes lacked a consistent level of detail, and requirements at a lower level may have applicability different from the higher level of 10 CFR in which they reside.
- Determination of applicable regulations at the time of application submittal may be influenced by ongoing rulemaking efforts at the agency.¹

Finally, the NRC noted the following process-related caveats:

- The key design criteria (see Section 2.1) noted by the NRC as a technical basis for their review must be met for a Kairos application referencing the TR.
- The NRC will “evaluate an application against the Commission’s regulations at the time of a license application submittal.” The safety evaluation “does not override the requirements within the regulations themselves.” During detailed review of an application, “subsequent NRC interpretations of its regulations...would take precedence over the positions in this TR.”²
- Despite the determination of applicability, future submittals might refer to some excluded requirements or the NRC might use excluded regulations to inform decisions.
- “Regulatory applicability may depend on the scope of the submittal” (i.e., combined license vs. construction permit).

The UIUC methodology described in this TR is aligned with the NRC approval of Kairos’ most recent submittal. This TR includes additional relevant information sought by the NRC.

Differences from the approved Kairos applicability determination of specific regulations derive primarily from the technology (HTGR vs. molten salt) and power rating category (research vs. test).

4.4. OKLO POWER, LLC

Whereas Kairos submitted a CPA under 10 CFR 50, Oklo Power LLC submitted a combined license application, intending to obtain a combined construction permit and operating license (COL) under 10 CFR 52. The application included an assessment of applicability of specific regulations. The Oklo license application was rejected by the NRC in January 2020. However, the NRC issued a letter (Reference 14) in November 2020 providing the results of NRC staff review of regulations that Oklo had identified as not applicable to its design. Because of the differences from the Oklo plant in design, licensing pathway, and research reactor designation, the NRC guidance to Oklo was not considered useful for the UIUC MMR.

4.5. UIUC MMR REGULATORY RELEVANCE

The regulations in 10 CFR Parts 1 through 199 were reviewed for applicability to the UIUC MMR

¹ As the “freeze date” for regulation applicability is generally six months prior to docketing, this statement is interpreted to not expect an application to address rulemaking in progress as of the freeze date.

² Presumably, “subsequent NRC interpretations of its regulations” means subsequent to approval of the TR, not subsequent to NRC issuance of the permit or license.

license application. Section 5.6 provides an explanation of the process used to determine relevance of regulations to the UIUC MMR project.

4.6. LICENSING ALTERNATIVES

As part of determining how to better accommodate reactor technologies different than assumed for regulations, the NRC has considered alternatives to the normal approach of either compliance with or exemption from regulations. As a result of internal assessments and the provisions of NEIMA, the NRC has focused on creating a new licensing framework by developing 10 CFR Part 53 for non-LWRs, which would take the place of Parts 50 and 52 for at least the technical requirements. Although the NRC is trying to expedite development of Part 53, the UIUC MMR schedule requires seeking a construction permit and operating license before Part 53 is expected to be ready.

In the meantime, the NRC has been pursuing a few initiatives in specific areas, as discussed in Enclosure 1 of SECY 20-0093 (Reference 18). These topics include physical security, emergency preparedness, staffing, aircraft impact, etc. Applicability to the UIUC MMR of revised regulations issued before the freeze dates for the CPA and OLA will be considered.

The NRC points out that procedural alternatives to exemptions have been used successfully in the past to license new technologies. Enclosure 2 of SECY 20-0093 (Reference 18) describes three licensing approaches:

1. Normal licensing process – use exemptions where needed and impose additional requirements through license conditions or rulemaking for non-LWR considerations. NRC identified minimal schedule impact but potentially adverse to standardization across different applications, burdensome documentation, because of the “relatively burdensome documentation preparation and associated review.”
2. Hearing order – a hearing order defining the applicable license review standards and any special standards or instructions. This approach was used for the Louisiana Energy Services, L.P., enrichment facility application. Although possibly most flexible, it was considered to have the highest likelihood of leading to litigation.
3. Rule of particular applicability – requirements tailored to a specific docket could allow for future efficiency gains if subsequent rulemaking for micro-reactors were desired by establishing a precedent. Disadvantages include considerable early applicant and staff effort and having to wait for the rule to be promulgated before issuance of the license.

An applicant may request that the staff develop a rule of particular applicability or an order (for example, as part of the Commission’s notice of docketing and opportunity to request a hearing on the application) to identify requirements particular to its design in lieu of or in addition to seeking exemptions from the applicable requirements. Orders and rules of particular applicability are case-specific, do not apply generically to all non-LWRs, and would require resources and substantial preapplication engagement. During pre-application engagement, the NRC staff and applicant would work together to identify areas where such an order or rule would be useful to clarify the relationship between current regulatory requirements and a

specific design and reduce or obviate the need for exemptions. These options are available for use in connection with a specific application, especially in cases where an applicant has a mature design and desires early Commission engagement. At this time, this approach is not anticipated to be used for the MMR.

This TR assumes the normal licensing process because it is more closely aligned with the experience of licensees and the staff. NRC stated that the exemption justification process also would be useful if the NRC decided to pursue project or design-specific rulemaking. Using non-applicability conclusions based on entry conditions will reduce the number of exemptions that need to be processed, thereby improving efficiency and timeliness of the UIUC CPA and OLA reviews.

4.7. ADDRESSING NRC STAFF QUESTIONS

UIUC submitted the original issue of this TR on December 9, 2022. The NRC staff suggested a public meeting be held to enable the staff to more efficiently ask questions regarding the basis for determining applicability of specific regulations. This meeting was held remotely on June 8, 2023. As a result of the meeting, UIUC determined there was a need to revise some of the information previously provided.

A second public meeting was held to discuss UIUC's RAI response letter to the NRC dated December 11, 2023 (ML23345A238) related to Release 02 of the TR, dated August 30, 2023 (ML23242A329). A meeting summary was provided to UIUC, dated January 31, 2024 (ML24012A035) with the NRC Staff Presentation Slides (ML24031A268). During the meeting, UIUC committed to provide an updated TR (Release 03) to include the RAI responses and to address NRC concerns discussed during the meeting, subsequently provided in the meeting summary.

Release 04 is being submitted to the NRC to remove UIUC's request for NRC approval of the methodology.

5.0 EXEMPTION PROCESS

5.1. PROCESS FOR EXEMPTIONS FOR 10 CFR 50

The NRC has a process for applicants to request exemptions from specific regulation(s) in the U.S. Code of Federal Regulations. Each major part of Title 10 of the Code of Federal Regulations has a process for requesting and justifying an exemption to a regulation if certain criteria are met. As the majority of licensing requirements applicable to the UIUC MMR are in 10 CFR 50, the exemption process defined in 10 CFR 50.12 is described below with modified wording for brevity and clarity.³

10 CFR 50.12(a) The Commission may grant exemptions to regulations in 10 CFR 50 that are

- (1) Authorized by law, will not present an undue risk to the public health and safety, and are consistent with the common defense and security
- (2) At least one of the following special circumstances must be present
 - (i) Conflict with other NRC rules or requirements
 - (ii) Applying the regulation is not necessary to achieve the intended purpose
 - (iii) Compliance would involve undue hardship or costs significantly in excess of those expected
 - (iv) The exemption would provide a net benefit to the public health and safety
 - (v) The exemption would provide only temporary relief from the applicable regulation
 - (vi) Other special circumstances not considered when the regulation was adopted

5.1.1. Exemption Process in Other Parts

The procedural requirements for other Parts of Title 10 are either similar or simplified. For example, Part 74 just states that the

“The Commission may, upon application of any interested person or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not endanger life or property or the common defense and security, and are otherwise in the public interest.”

5.2. SUITABILITY OF AN EXEMPTION

The purpose of the exemption requests for non-LWRs such as the MMR is to acknowledge acceptability of differences in technical and design bases and administrative functions to justify how to ensure the health and safety of the public and protection of the environment. Each exemption request is expected to include a specific explanation of how these criteria will be met.

³ Note that 50.12(b) pertains to an exemption that would allow performing activities in advance of issuance of a construction permit and is omitted, as it is not relevant to the topic at hand, which is applicability of regulations to a non-LWR research reactor.

In general, the basis for an exemption will be:

- Technical and regulatory criteria were developed primarily for LWRs and do not address alternative HTGR design features. Their use will not present an undue risk to the public health and safety and is consistent with the common defense and security.
- One or more of the following special circumstances exist
 - Applying the regulation is not necessary because the non-LWR design provides protection of the public and environment through alternative means.
 - Compliance would involve undue hardship or costs significantly in excess of those expected. For example, imposition of the regulation for emergency ac power would require substantial additional cost for a design accomplishing long-term cooling by passive means.
 - When 10 CFR 50.12 for granting of exemptions was issued, the focus was on LWR safety. Licensing of reactors using alternative technologies to accomplish protection of the public and environment for a non-LWR was not addressed when the regulation was adopted.

5.3. EVALUATIONS OF REGULATORY CONSIDERATIONS FOR NON-LWR TECHNOLOGIES

SECY-20-0093, "Policy and Licensing Considerations Related to Micro-Reactors" (Reference 18) discusses licensing topics related to low power reactors that may necessitate departures from current regulations, related guidance, and past precedents.

"Some NRC regulations are written as prescriptive requirements independent of the size and potential consequences of the facility and would likely give rise to exemption requests in micro-reactor applications. In particular, prescriptive staffing and operational requirements developed with large LWR facilities in mind may be more extensive than micro-reactors require to operate safely. Provided a micro-reactor applicant can demonstrate the safety and security of its design and show the facility represents a low risk, the staff recognizes that different licensing and regulatory approaches are appropriate for such facilities...."

"Because of the significant differences between large LWRs and micro-reactors, the staff is receptive to requests for exemptions from the existing regulations in the areas above and would evaluate such exemptions on a case-by-case basis using existing agency processes..."

"In the near term, the staff plans to license micro-reactors under the existing regulations for power reactor licenses in 10 CFR Parts 50 and 52."

The viability of a microreactor project hinges on predictable, efficient regulatory review. Studies performed by and for the NRC have repeatedly acknowledged the inefficiency of attempting to apply regulations tailored for LWRs to non-LWRs.

- In 2016, "NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness" (Reference 19) commented on the efficiency of review of non-LWR applications using regulations and policy aimed at LWR designs:

“The NRC is fully capable of reviewing and reaching a safety, security, or environmental finding on a non-LWR design if an application were to be submitted today. However, the agency has also acknowledged the potential inefficiencies for non-LWR applications submitted under 10 CFR Part 50 or Part 52 that are reviewed against existing LWR criteria, using LWR-based processes, and licensed through the use of regulatory exemptions and imposition of new requirements where design-specific review, analysis, and additional engineering judgement may be required.”

- In a briefing for the Commission on April 24, 2018 (Reference 20), a member of the staff of the Office of New Reactors stated:

“With respect to the existing regulatory structures of CFR Part 50 and Part 52, we believe that they offer flexibility, but not necessarily efficiency. While we have said many times that we can review advanced reactors using the existing regulations, we have also been clear regarding the inefficiency associated with a large number of exemptions. If the resources were available, particularly off-fee based resources, I believe that revising our regulatory requirements to more clearly align with the wide spectrum of potential technologies and uses in a risk-informed and performance-based manner, would significantly increase our review efficiency. It will also be important for us to incorporate the Commission's direction to use risk-informed, design-specific review standards for small modular reactors into our approach for advanced reactor reviews.”

- Further, a 2019 review conducted by Brookhaven National Laboratory that was commissioned by NRC (Reference 21) stated:

“Currently, review and licensing of non-LWR applications requires submittals under 10 CFR Part 50 or 52 that are reviewed against existing LWR criteria, developed largely based on experience with LWR technology, and would necessitate the use of regulatory exemptions and imposition of new requirements where design-specific review, analysis, and additional engineering judgment is required. The vision and strategy, when implemented, is developed to address these potential inefficiencies and provide regulatory certainty for non-LWR applicants.”

- The Government Accountability Office (GAO) 2015 report “Nuclear Reactors -Status and challenges in development and deployment of new commercial concepts” (Reference 22) identifies information provided by the NRC that acknowledges the difficulty of use of exemptions for non-LWR licensing:

“Because of the need for more adjustments and exemptions to apply these processes to an advanced reactor design, time frames for an advanced reactor design would be longer, according to DOE and NRC officials and members of our expert group...”

“Furthermore, the current NRC certification or licensing processes were described to us by former and current NRC staff as being focused on the reactors that have been built—that is, large LWRs. According to reactor designers, certifying or licensing an

advanced reactor may be particularly time-consuming and difficult, and the need for exemptions to and interpretation of the current processes if applied to advanced reactors could introduce economic uncertainty for the applicants...

"According to the NRC, any new reactor technology can be certified or licensed using existing 10 CFR Part 50 or 52 regulations. However, these deterministic regulations were developed for existing large LWRs, so exemptions would be needed for reactor designs differing significantly from existing large LWRs, or the regulations would otherwise need to be adapted, according to reactor designers and NRC officials. According to NRC officials, these exemptions must be specifically applied for by reactor designers or license applicants before the NRC will actively pursue them, and the pre-application discussions between reactor designers and NRC are intended to help identify these exemption items. Several reactor designers told us that they would like regulations changed in order to lessen the uncertainty introduced by relying on exemptions during the DC or licensing process. According to reactor designers, the uncertainty associated with the need for exemptions increases their development risk by potentially increasing the length of the multiple year DC or license application process..."

The above and other references identify considerable effort to license non-LWRs by requesting exemptions to existing regulations. This TR justifies an approach to alleviate the effort associated with licensing the UIUC MMR to regulations intended for LWRs and to satisfy Congressional direction in NEIMA without any reduction in the level of safety for the UIUC MMR.

5.4. EXCLUSION VS. EXEMPTION – ENTRY CONDITIONS OBVIATE EXEMPTIONS

As discussed in Section 4.1, NRC regulations already contain entry conditions to direct licensees regarding limited or generic applicability. Exemptions requested should be minimized for the following reasons:

- Focus attention during review on those matters where an applicant proposes to deviate from established requirements
- Reduce use of NRC staff resources on matters already addressed in the regulations
- Promote licensing consistency among similar designs
- Avoid the impression that the NRC is waiving/relaxing safety requirements (i.e., "regulating by exemption")
- Requiring an applicant to request exemptions from regulations explicitly labelled as applicable to other designs/activities is inconsistent with NRC's Principles of Good Regulation (Reference 23):
- Efficiency: "...Where several effective alternatives are available, the option which minimizes the use of resources should be adopted..." Using an entry condition to identify regulations designated as not having applicability avoids the applicant and NRC staff effort to process an exemption to an already excluded condition.

- Clarity: "Regulations should be coherent, logical, and practical. There should be a clear nexus between regulations and agency goals and objectives whether explicitly or implicitly stated. Agency positions should be readily understood and easily applied." If regulations with entry conditions such as "For light-water cooled reactors" are not treated as written (i.e., plain language), applicants and the public will not be able to determine NRC staff expectations in advance of submittal of applications.

5.5. NRC STAFF POSITIONS ON EXEMPTION REQUESTS

NRC guidance discusses licensing non-LWRs to a regulatory framework that mostly assumes large, power LWRs. The process for exemption requests in 10 CFR 50.12 and elsewhere was expected to be used infrequently to accommodate individual design deviations from the regulations. As such, the process entails considerable effort and time from the applicant and the NRC staff. For advanced reactors, a large number of regulations would need permanent exemptions today because the accumulation of LWR-specific guidance without formally issued alternative HTGR criteria leaves a gap in regulatory direction. The NRC has conducted numerous evaluations and meetings regarding this situation, and proposed resolution continues to be a work in progress.

The draft staff white paper treatment of exemptions evolved from Reference 4 to Reference 12. Although marked as "draft," "not for use," "subject to change," and "should not be interpreted as official agency positions," to Reference 12 provides the most current, detailed, and broad assessment of applicability of extant regulations to non-LWRs. As the NRC has not yet issued official guidance, References 4 and 12 have been used to inform this UIUC MMR TR. The following describes substantive differences among drafts pertaining to the exemption request process.

5.5.1. Original September 2020 draft

The white paper (Reference 4) states that applicants may request exemptions on a case-by-case basis. Then, the NRC will determine if the proposed exemption is authorized by law.

- For a regulation generically not applicable to any non-LWR, the application does not need to include any further information.
 - TMI requirements per 10 CFR 50.34(f) are not applicable to 10 CFR 50 non-LWR applicants. However, Part 52 applicants must address 50.34(f) subject to some exceptions. NRC states that Part 50 applicants shall consider 50.34(f) as applicable in accordance with SECY-15-0002 (Reference 24), which was approved by Staff Requirements Memorandum (SRM) dated September 22, 2015.⁴
- For those regulations generically applicable to non-LWRs, then;

⁴ Although this SRM was issued in September 2015, the NRC regulations have not been revised to implement it. The NRC has taken the position that these regulations must be evaluated for non-LWRs licensed under Part 50 based on the SRM, pending rulemaking. They were included in the review, as shown in Attachment 1.

- Provide information in the application as to how the requirement is met.
- Table 1 lists areas where the NRC anticipates exemptions.
- If not met, the application must provide a technical justification if requesting an exemption as follows.
 - Identify specifically for what portions of the regulation that an exemption is being requested.
 - Identify at least one special circumstance per 10 CFR 50.12(a)(2) as part of justification for the exemption.
- Exemption requests should be in their own section of the application.
- Exemption requests need not repeat technical information presented elsewhere in the application (i.e., reference the relevant portion of the application). Exemption requests using the same technical justification can be bundled together into a single request at the applicant's discretion.
- An exemption may not always be required, as non-LWR designs may meet a rule through design and application-specific implementations.
- In other cases (e.g., 50.55a), the regulations may be applicable but not pose requirements
- Each applicable exemption request will need to be included in the individual licensing action or design certification applications.

5.5.2. Revised July 2021 draft

This section identifies the more significant changes from the September 2020 draft. Note that the numbering of tables differs from the September 2020 draft. Also, an interim revision is not discussed.

- The NRC staff acknowledged that some regulations considered generically applicable may not serve a purpose for certain non-LWR designs.
- Applicants will be required to submit on the docket the information needed to support staff's determinations on the acceptability of each exemption request.
 - As the application will provide information regarding the overall safety of the design, some or all of the basis for exemptions from regulations may be addressed in the application without need for additional justification.
 - The justification for exemption requests will vary. As long as the administrative record demonstrates that the regulatory requirements are met and the exemption request is justified, the NRC considers it acceptable for the format and content of the exemption to differ.
 - In a few special cases, something other than a full exemption request may be appropriate.
 - For regulations inapplicable because of entry conditions already in the rule, applicants should document and support their claim that a requirement is inapplicable because of the entry condition.
 - The NRC will determine if the proposed exemption is authorized by law, which includes identifying at least one special circumstance per 10 CFR 50.12(a)(2).
 - For requirements under 10 CFR 50.34(f) (i.e., Three Mile Island (TMI)

requirements) regulations are considered not applicable if entry conditions are not met.

- Regulations listed in Table 5 are associated with three topical areas (fission product release, criticality, and RCPB). Although the underlying concern applies to all reactor designs, the regulations include provisions specific to LWR designs. The NRC staff anticipates non-LWR exemptions from these regulations, but the precise nature of each requested exemption will depend on the specific technology and how other regulations are being met. The NRC staff will afford applicants as much flexibility as possible in meeting the underlying purpose of these regulations.

In each of the draft versions, the staff repeatedly emphasizes the importance of early engagement on these topics to facilitate an efficient and effective review.

Note that the July 2021 draft gives more weight to use of entry conditions that are already present in the rule to determine applicability. In these cases, applicants are expected to document and support their claim that a requirement is inapplicable because of the entry condition. Previously, the NRC had espoused the position that not meeting a regulation with an entry condition that limited applicability to LWRs still required an exemption. However, the July 2021 version of the staff draft white paper acknowledges that when a regulation is clearly inapplicable because of conditions limiting its scope, documenting the basis for inapplicability is sufficient, and an exemption need not be requested (see of this TR, second row rightmost box and fourth row second box from left).

5.5.3. Interim Staff Guidance

The draft ISG (Reference 17) previously discussed in Section 4.2 identifies scenarios where a regulation may not be applicable and if an exemption request may be appropriate.

If a non-LWR design satisfies an applicable regulation via an alternative approach (e.g., rule of specific applicability), an exemption may not be required if the underlying safety requirement can be shown to be met and appropriately documented.

5.6. UIUC APPROACH

As stated previously, the draft NRC guidance discussed in the above sections provides the best available, albeit unofficial/draft, information on the NRC staff perspective on applicability of specific regulations to non-LWRs. The NRC subsequently approved the Kairos process for determining applicability, but for the UIUC MMR, the initial determination of regulatory applicability was made independently of the NRC draft guidance, which was then used to review the suitability of the rationale. As the UIUC MMR is a research reactor, an additional entry condition is considered. This results in regulations potentially applicable to a non-LWR being excluded.

The alignment between UIUC MMR RAG assignments and the draft NRC guidance can be summarized as:

- If an entry condition in a regulation or the heading of the regulation plainly states it is applicable to a
 - a) LWR (or other similar terms such as water-cooled), PWR, or BWR,
 - b) to non-reactor facilities;
 - c) to licensing only under Part 52; or
 - d) applications already submitted,
 then it is likely RAG 1 N/A, to be confirmed by due consideration given to each subpart of each regulation. If an entry condition in a regulation or the heading of the regulation plainly states it is applicable to a stationary power reactor or nuclear power reactor (or plant) or not applicable to a research reactor, then it is RAG 2 N/A to NPUF. No justification other than the UIUC reactor being a Class 104(c) research reactor not meeting the entry condition is required.
- If the regulation is not excluded by an entry condition and will be satisfied, it is in one of several subgroups to distinguish among several variations.
 - 3 Applicable as is – regulations that are relevant without further consideration
 - 3A Modified/partial – regulations that are not written in a manner suitable for application to the UIUC MMR
 - 3B Meets intent – regulation applies, with some specific limitations or modifications, not clearly acknowledged in the regulations but which are not considered to be significant deviations that require an exemption. This RAG is infrequently used but is useful where the combination of the UIUC MMR being a non-water, non-power reactor results in potential uncertainty in how the regulation should be met.
 - 3C Administrative – for efficiency, applicable requirements not relevant to design or technical aspects are grouped separately
 - 3D NRC, not applicant – some NRC regulations in Parts 1 to 199 of Title 10 pertain to operation of the NRC, not to applicants or licensees.
- If an excluded regulation contains guidance that is safety-significant but not addressed in other applicable regulations or NUREG-1537, then excluding it could leave a gap. The need for alternative actions to address a gap will be assessed as part of performing the safety analysis. The regulation is still marked as non-applicable.
- Finally, for regulations not excluded by entry conditions and not planned to be met, exemptions must be requested, as noted by RAG 4.

Table 5-1 outlines the steps of the process used to assess regulation applicability. Attachment 1 of this TR is the results of the assignment of individual parts, sections, and paragraphs to specific RAGs and the rationale for determinations other than Applicable As-is or Administrative. Color coding is used to readily distinguish the RAG assignment (in particular, N/A determinations are dark shading with white font).

Table 5-1. Steps in Process to Evaluate NRC Regulation Applicability to UIUC MMR

Step	How Applicability of Regulations Evaluated	Remarks
1	Search 10 CFR 50 Parts 1 to 199 for key distinguishing terms such as "non-power," "NPUF," "power plant," "water-cooled," "pressurized water," etc. to identify entry conditions to create a list of potentially excluded regulations.	Location of entry conditions varies (e.g., in title, in first sentence of paragraph, within a subpart, at end). Because of the complex organization of several parts, determining applicability involved considerable cross-checking of various parts.
2	Compare to Kairos TR test reactor list (Reference 13) and the NRC response (Reference 5) and reconcile differences.	Most differences result from distinction between test and research reactors
3	Compare to guidance in the NRC staff draft white paper (Reference 12) tables 1) 10 CFR 50 regulations potentially applicable to non-LWRs 3) Regulations other than 10 CFR 50 and 52 (NRC list usually does not distinguish below part level) 4) 10 CFR 50.34(f) TMI requirements 5) areas with anticipated exemptions Reconcile differences.	Most differences result from research reactor designation, some from HTGR technology (e.g., functional containment), and some from both (e.g., 10 CFR 50.46 and 10 CFR Appendix J are not applicable to non-power reactors or to HTGRs.
4	Compare to NUREG-1537 (Reference 6) App. A listing of regulations applicable to non-power reactors, including test reactors and reconcile differences.	For example, 10 CFR 37 had been identified as applicable but was not listed by NUREG-1537 App. A, which was based on 1995 CFR, whereas this Part was added in 2013.
5	For a few regulations where some question remained, review federal register statements of consideration associated with the regulation or subpart thereof, review licensed research reactor safety analysis and evaluation reports and/or search for other NRC guidance.	Generally, the higher power research reactors were considered. Other NRC guidance included staff papers (SECYs), federal register rulemaking narratives, etc.

5.7. REQUESTING AND JUSTIFYING EXEMPTIONS

Means for documenting the basis for determination of applicability and need for an exemption are described in the NRC staff draft white paper (Reference 12):

- Although each exemption could be individually justified, applicants may provide information related to the overall safety of the design and, thereby, justify multiple exemptions. Exemption requests using the same technical justification can be bundled together into a single request at the applicant's discretion.
- Exemption requests ideally should be in their own section of the application, although the exemption requests need not repeat technical information presented elsewhere in the application (the exemption request can reference the relevant portion of the application).

- Applicants will be required to submit on the docket the information needed to support staff's determinations on the acceptability of each exemption request.
- Exemption requests will vary both in content and complexity, and the amount of supporting information needed to justify the technical and regulatory criteria associated with a specific exemption request will vary accordingly. Provided the docketed information demonstrates that the regulatory requirements are met and provides appropriate justification, the format and content of the exemption may vary.

The NRC notes there may be instances where less than a full exemption request may be appropriate, such as entries in the definitions sections or lists of codes and standards which do not impose requirements unless they are referenced in other applicable regulations. Some exemption requests are straightforward enough that providing a basis for them requires little information beyond the description of the design in the final safety analysis report (FSAR) as technical justification.

5.8. NRC REVIEW OF EXEMPTION AND RECOMMENDATIONS FOR NON-APPLICABILITY

The most recent draft staff white paper (Reference 12) discusses NRC actions to process exemption requests. To review the propriety of exemptions, the NRC has identified some process requirements:

- Applicants will be required to submit on the docket the information needed to support staff's determinations on the acceptability of each exemption request.
- While some NRC regulations are generically not applicable to non-LWRs, the NRC staff will review applications to ensure that any particular non-LWR design achieves the underlying safety purpose of each such regulation if needed for adequate protection of public health and safety or the common defense and security.
- Although not applicable to the UIUC MMR being licensed under Part 50, the most recent draft staff white paper (Reference 12) states that NRC will prepare and evaluate exemptions for Part 52 regulations that reference Part 50 regulations applicable only to LWRs, even when not requested by the applicant. The white paper notes that the staff reserves the right to request additional information from the applicant.

5.9. UIUC MMR EXEMPTION REQUESTS

Based upon the foregoing guidance and considerations, UIUC MMR exemption requests will be handled as follows:

- Where an exemption to an existing regulation is needed because it is neither excluded by an entry condition nor met for the UIUC MMR, the exemption request will be formally submitted to the NRC with accompanying justification.
- Exemption requests and their justifications will be consolidated in one section of the CPA and OLA, with reference to detailed supporting data elsewhere in the submittals.
- Exemptions will not be requested for those items where the UIUC MMR design meets the underlying intent of a regulation particular to LWRs. See Attachment 1 for regulations assigned to RAG 3B (e.g., 50.36(c)(2)(ii)(a), Reactor coolant pressure boundary) for which the MMR will meet the intent but not the particular method of implementation.

NOTE: This TR does not include any requests for exemptions from NRC regulations. Any actual exemption requests would be provided at a later time, such as with the construction permit and/or operating license application.

6.0 SUMMARY OF PLANNED APPROACH

The UIUC 10 CFR 50 CPA will take the following approach to identify and justify exclusions and exemptions from appropriate regulatory requirements for the non-LWR MMR technology and reactor design. Regardless of regulation applicability, the UIUC MMR will need to demonstrate that protection of the health and safety of site personnel and the public and protection of the environment are provided. The proposed approach is in recognition that justifying acceptability of not complying with regulations that are on the face applicable to other reactor technology is not only inefficient for the applicant and the NRC, but also distracts from evaluation of the safety basis.

In summary: the UIUC MMR approach identifies if an NRC regulation must be met by assessing each regulation as applicable or not on the basis of entry conditions. For those not applicable, the reason will be documented in a formal record. For those applicable, license submittals will detail the method of compliance. If the regulation is applicable but the prescription for compliance is not appropriate, the means and justification for meeting the intent or a suitable modification of the compliance details will be provided. For those found applicable where an alternative is needed, an exemption will be requested and the rationale provided in license submittals and supporting documents. In most cases, the special circumstances for the requested exemption will be differences between the UIUC MMR high temperature gas-cooled research reactor and long-standing LWR-based regulatory framework.

Because of the above criteria, few exemptions will need to be requested for the UIUC MMR, leading to a more efficient and timely review. The results of the regulatory assessment of individual regulations are provided in Attachment 1.

6.1. EXPECTED EXEMPTIONS

As shown in Attachment 1, few exemptions have been found to be necessary. Use of the entry conditions pertaining to various types of water-cooled reactors and to power reactors excluded virtually all regulations that would have required exemptions, with the exception of the following.

6.1.1. Security and Safeguards

In 10 CFR 73 and 74, which are for physical protection of plants and materials and for material control and accountability, the NRC provides direction to protect against diversion of SNM and against radiological sabotage.

Based solely on the maximum enrichment and amount of ^{235}U in the MMR core, the UIUC facility will have SNM of moderate strategic significance. The MMR core is comprised of HALEU-containing TRISO particles bonded into silicon carbide FCM pellets that are, in turn, loaded into graphite blocks. The MMR core assembly and installation approach is under development.

The MMR plant is protected against external physical threats by several features:

- Fuel enrichment is below 20%.
- The fuel form has a low density of fissionable material making it an unattractive

target for diversion.

- Fission product retention barriers are robust and unlikely to be degraded by damage to plant equipment caused by malevolent acts.
- The entire nuclear plant is enclosed in a below ground concrete citadel.
- Radiation levels and temperatures in the reactor cavity after a short period of initial operation will be high enough to preclude access by adversaries.
- The core is infrequently refueled.
- The low power density simplifies decay heat removal so that no electrical power or SSCs vulnerable to active failures or sabotage serve as possible targets. Thus, the potential for malevolent attack to cause radiological release is low.
- Fuel damage with release of fission products will be shown not to occur for a rupture of the helium boundary and complete depressurization.
- The low power rating creates a small radionuclide source term, presenting a small risk to the health and safety of the public.

Therefore, the UIUC MMR is not an attractive potential target with vulnerability to radiological consequences.

Reference 26 discusses evolution of NRC staff approach to safeguards against diversion of SNM. In place of an initial concept using multiple parameters to define SNM attractiveness, the staff focused on considering only dilution, which corresponds “to the difficulty of acquiring and processing SNM.” “Dilution factor” for solids would be defined as the weight of fissile material divided by the total weight of the SNM material and non-SNM materials which are not mechanically separable from the SNM.⁶ For MMR fuel blocks, the dilution factor would be near the lower end of moderately dilute.

As proposed in the staff evaluation, the safeguards requirements for the UIUC MMR would be the second to lowest, called “Category II – moderately dilute.” Reference 26 states that physical protection measures would be tailored for individual categories and attractiveness levels, which will allow adjusting for differences in material form, size, etc. Table 4-3 of Reference 26 summarizes the protective measures (e.g., access control point search, periodic patrols) but does not require a protected area with security detection nor armed security officers.

UIUC may request an exemption/relaxation of certain safeguards and security regulations to treat the largely inaccessible SNM as low strategic significance and to simplify physical security measures in 10 CFR 73.

In addition, as the core is not accessible and SNM is infrequently stored outside the reactor vessel, simplified physical inventory/accountability actions will be proposed. The details of what deviations from specific regulations will be included in the CPA.

⁵ SECY-19-0062 also includes a revision of the accident radiation exposure limits for research reactors that would raise the limit from the 10 CFR 20 value for normal operation to 1 rem, consistent with the safety basis of many operating non-power reactors. The timing of action on this final rulemaking is uncertain. If implemented, it will affect a few of the regulation applicability determinations in Attachment 1. Any changes will be addressed in the CPA or OLA. A change in the proposed rulemaking to the definition of an NPUF would not change the relevance or conclusions of this TR.

⁶ Mechanically separable is defined as being accomplished by a simple mechanical operation that does not require specialized tools or processes and that does not considerably increase the adversary’s mission timeline (time-on-target). In a case of a typical non-power reactor fuel element, SNM cannot be separated from the aluminum matrix of the fuel without chemical processing. Also, the

fuel mixture is mechanically bonded to the aluminum cladding and it cannot be separated from the cladding without chemical and/or complex mechanical processing. In this example, SNM is not mechanically separable.

7.0 REFERENCES

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Attachment 1

Assignment of NRC Regulations to UIUC-MMR Regulation Applicability Groups

Attachment 1

Explanation of RAG Table Columns

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group (RAG)	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
Parts 1 to 199	Identifying number and title of regulation Rows split up individual Parts (Chapters) of NRC regulations down to the lowest paragraph level to ensure than requirements are properly characterized: <ul style="list-style-type: none">- In some cases, a whole Part can be assigned to a single RAG- A Part may have all in one RAG with the exception of a few regulations- In some instances, individual paragraphs must be listed to capture entry condition differences	See table key on previous page	Provides clarifying notes to explain reason for assignment to a RAG, differences from NUREG-1537 Appendix A, Kairos topical report, etc.

The Regulation Applicability Group column is formatted to help distinguish different categorizations of regulations. A dark color with white italics font is used for any regulation deemed not applicable (e.g., because of entry conditions). Specifically, the format key is:

Group	Basis
1 N/A	HTGR/MMR technology differs in fundamental ways from that of LWRs. The capability, system, or feature is not required. Regulations in this group are not applicable because they have entry criteria (see Section 4.1) pertaining to: <ul style="list-style-type: none"> • Facility type: those that are not a utilization facility (i.e., not a reactor) • Reactor type: specifically applicable to a LWR (PWR, BWR) or D₂O • Specific time frame: applications submitted prior to 2023 • Specific license application: those that reference a specific project • Application type: other than Part 50 construction permit and OL
2 N/A to NPUF	NPUFs do not need to meet regulations that have entry conditions pertaining to a “nuclear power plant,” “power reactor,” or similar. Based upon UIUC qualifying for a Class 104(c) license, which is a non-power production or utilization facility (NPUF), the power reactor regulations are not applicable.
3 Applicable as is	Regulation applies, although there may be sub-paragraphs that have their own specific entry conditions as noted
3A Modified/partial	Regulation applies, with some specific limitations or modifications, which are not considered to be significant deviations that require an exemption, or where portions down to the paragraph level may not be applicable and would be so noted as N/A in the subsequent row(s).
3B Meets intent	Regulation applies and the underlying safety basis is relevant, but the means of implementation are subject to interpretation. The UIUC approach is considered to meet the intent of the regulation and not require an exemption. An alternative approach would be more appropriate for the MMR design to meet the regulation. This will be provided in the PSAR and FSAR.
3C Administrative	Applies but does not affect design or technical requirements.
3D NRC, not applicant	Regulation pertains to NRC activities not relevant to an applicant or licensee.
4 Request exemption	UIUC may deviate from the regulation. UIUC may request an exemption.

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
1	Statement of organization and general information	3D NRC, not applicant	NRC organizational information
2	Agency Rules of Practice and Procedure	3C Administrative	
4	Nondiscrimination in Federally assisted programs or activities receiving Federal financial assistance from the Commission	3D NRC, not applicant	NRC administrative procedures
5	Nondiscrimination on the basis of sex in education programs or activities receiving Federal financial assistance	3C Administrative	
7	Advisory committees	3D NRC, not applicant	NRC organizational information
9	Public records	3C Administrative	
10	Criteria and procedures for determining eligibility for access to restricted data or national security information or an employment clearance	3D NRC, not applicant	NRC administrative procedures
11	Criteria and procedures for determining eligibility for access to or control over special nuclear material	2 N/A to NPUF	11.11(a) specifies non-power reactor facilities and storage of fuel thereto are excluded 11.13 excludes non-power reactors from transport regulations by reference to 10 CFR 72.20, 25, 26, and 27 N/A to NPUF is consistent with 1537 App. A
12	Implementation of the Equal Access to Justice Act in agency proceedings	3D NRC, not applicant	NRC administrative procedures
13	Program fraud civil remedies	3C Administrative	
14	Administrative claims under Federal Tort Claims Act	3C Administrative	
15	Debt collection procedures	3C Administrative	
16	Salary offset procedures for collecting debts owed by Federal employees to the Federal government	3D NRC, not applicant	NRC administrative procedures
19	Notices, instructions and reports to workers: inspection and investigations	3C Administrative	
20	Standards for protection against radiation including appendices, except	3 Applicable as is	
	20.1301(e) EPA 40 CFR 190 radiation standards	2 N/A to NPUF	Differs from 1537: 40 CFR 190 limited to power production for public use
	20.1406(b)	2 N/A to NPUF	For applicants under Part 52;
	20.2004(b)(1) incineration of waste on-site	2 N/A to NPUF	UIUC MMR is NPUF, not power reactor licensed under Part 50

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	20.1905(g)	2 N/A to NPUF	UIUC MMR is a NPUF, not a power reactor licensed under Part 50.
	20.2201(b)(2)(i) Written reporting	2 N/A to NPUF	Holders of an OL for a nuclear power plant; instead use (b)(ii)
	20.2203(c)	2 N/A to NPUF	Holders of an OL for a nuclear power plant; instead use (d)
21	Reporting of defects and noncompliance	3 Applicable as is	Not listed in NUREG 1537 App. A. Basic component definition: 21.3(1)(i) is for nuclear power plants, (ii) specifies quality assurance per 10 CFR 50 App. B, which is N/A to NPUF, (2) is for Part 52 licensing, and (3) is for facilities other than nuclear power plants. Therefore, UIUC basic components are as defined in 21.3(3). Similarly, commercial grade item and dedication apply via (2) and critical characteristics and dedicating entity apply despite nuclear power plant entry condition.
	21.3 Definitions: basic component, commercial grade item, dedication	3B Meet intent	Some definitions may require clarification (e.g., Safety-related structures, reactor coolant pressure boundary, basic component); these will be identified in PSAR
25	Access authorization	3C Administrative	
26	Fitness for duty programs	2 N/A to NPUF	UIUC MMR is NPUF; entry condition in 26.3(e) "This part does not apply to ...non-power reactor licensees who possess, use, or transport formula quantities of irradiated SSNM." UIUC will implement alternative security measures with suitable access authorization provisions per 10 CFR 37 subpart B.
30	Rules of general applicability to domestic licensing of byproduct material, except	3 Applicable as is	UIUC MMR is NPUF; 1537 App. A states: "Non-power reactor licenses issued under 10 CFR Part 50 contain authorization to receive, possess, and use byproduct material pursuant to 10 CFR Part 30. The Part 50 license states that the receipt, possession, and use of byproduct materials as authorized by the license will be in accordance with the Commission's regulations in 10 CFR Part 30 including Section 30.33." NOTE: §30.12, 30.21 and 30.32(i) do not apply to nuclear reactors
	Appendix D	2 N/A to NPUF	App. D is not applicable per 1537 App. A. Applies to commercial companies.
31	General domestic licenses for byproduct material	3 Applicable as is	
32	Specific domestic licenses to manufacture or transfer certain items containing byproduct material	1 N/A	Application for specific license not required for reactors.

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
33	Specific domestic licenses of broad scope for byproduct material	1 N/A	Application for specific license not required for reactors.
34	Licenses for industrial radiography and radiation safety requirements for industrial radiographic operations	1 N/A	Radiography performed by licensed subcontractor
35	Medical use of byproduct material	1 N/A	UIUC MMR is not used for production of radioisotopes for medical or other purposes.
36	Licenses and radiation safety requirements for irradiators	1 N/A	UIUC MMR is not designed to be used as an irradiator
37	Physical protection of category 1 and category 2 quantities of radioactive material; Subpart A General Provisions, except	3C Administrative	Part 37 was added by 78 FR 17007, Federal Register / Vol. 78, No. 53 / Tuesday, March 19, 2013. Therefore, it is not listed in 1537 App. A, which was based on 1995 CFR.
	Subpart B, 37.21 to 37.33 - Background Investigations and Access Authorization Program Subpart C, 37.41 to 37.57 - Physical Protection Requirements During Use	1 N/A	10 CFR 37.11(b) exempts activities under subparts B & C included in security plan required by Part 73.
	37.73 Physical protection in transit	1 N/A	Applies to shipping licensee (i.e., transporter)
39	Licenses and radiation safety requirements for well logging	1 N/A	Not applicable to reactors
40	Domestic licensing of source material	1 N/A	Not applicable to reactors
50	Domestic licensing of production and utilization facilities	3A Modified/partial	See breakdown below.
	50.1 Basis, purpose, and procedures applicable.	3C Administrative	Applicable as is or 3C Administrative, except as noted
	50.2 Definitions.	3B Meet intent	Some definitions may require clarification (e.g., Safety-related structures, reactor coolant pressure boundary, basic component); these will be identified in PSAR.
	50.3 Interpretations.	3C Administrative	
	50.4 Written communications.	3C Administrative	UIUC MMR is 50.21(c) research reactor; use 50.2(b)(2)(i) address for applications
	50.5 Deliberate misconduct.	3C Administrative	
	50.7 Employee protection.	3C Administrative	
	50.8 Information collection requirements: OMB approval.	3C Administrative	
	50.9 Completeness and accuracy of information.	3C Administrative	
	50.10 License required; limited work authorization.	3 Applicable as is	UIUC does not currently plan to request a LWA or ESP

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	50.11 Exceptions and exemptions from licensing requirements.	1 N/A	Differs from 1537: UIUC is not an organization to which this is applicable
	50.12 Specific exemptions.	3C Administrative	Process for determining need for exemptions and to justify them is described in TR Section 5.
	50.13 Attacks and destructive acts by enemies of the United States; and defense activities.	3 Applicable as is	
	50.20 Two classes of licenses.	3C Administrative	
	50.21 Class 104 licenses; for medical therapy and research and development facilities.	3 Applicable as is	UIUC MMR qualifies for Class 104(c) license research reactor
	50.22 Class 103 licenses; for commercial and industrial facilities.	3 Applicable as is	Will not exceed 50% threshold; See 50.21
	50.23 Construction permits.	3 Applicable as is	UIUC will submit applications for CP per 10 CFR 50
	50.30 Filing of applications for licenses; oath or affirmation.	3C Administrative	
	50.31 Combining applications.	3C Administrative	
	50.32 Elimination of repetition.	3C Administrative	
	50.33 Contents of applications; general information, except as noted	3 Applicable as is	
	(f)(3) Info required for Part 52 COLA	1 N/A	Differs from 1537: applies to COL under Part 52
	50.34 Contents of applications; technical information, see below.	3A Modified/partial	3A because of individual regulation variation shown below
	(a)(1)(i)	3 Applicable as is	UIUC MMR is NPUF HTGR; entry conditions in 50.34(a)(1) directs non-power applicants to (i), which references part 100, but part 100 in N/A to research reactors. (a)(1) applicable per NUREG-1537 App. A.
	(a)(1)(ii) Stationary power reactor applicants after 1996	2 N/A to NPUF	Applicable per NUREG-1537 App. A. Differs from 1537 which was issued in 1995.
	(a)(2) Summary description of facility	3 Applicable as is	Applicable per NUREG-1537 App. A.
	(a)(3) Preliminary design of the facility	3 Applicable as is	UIUC MMR is NPUF MHTGR. Listed as applicable to NPUF per NUREG-1537 App. A. NRC RG 1.232 establishes MHTGR-DC that replace GDC without need for an exemption and that may be applied to NPUF per Footnote 4. UIUC PDC TR submitted to the NRC satisfies this requirement.
	(a)(4) Preliminary analysis of design and performance, including 50.46 and 50.46a.	3A Modified/partial	MMR is NPUF HTGR; 50.46 N/A because has entry condition in title limiting to power LWRs (see 50.46)

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	(a)(6) Preliminary plan for organization, training, and operations	3 Applicable as is	
	(a)(7) Description of QA plan	3 Applicable as is	UIUC MMR is NPUF, applicable per NUREG-1537 App. A. 10 CFR 50 App B N/A per entry condition.
	(a)(8) SSCs requiring R&D	3 Applicable as is	
	(a)(9) Technical qualifications of applicant	3 Applicable as is	
	(a)(10) Preliminary plan for emergencies	3 Applicable as is	
	(a)(11) Applicants for CPs on multiunit sites	2 N/A to NPUF	UIUC MMR is non-power research reactor
	(a)(12) Stationary power reactor CPA comply with App S	2 N/A to NPUF	UIUC MMR is non-power research reactor
	(a)(13) Power reactor applicants submit 50.150(b) info	2 N/A to NPUF	UIUC MMR is non-power research reactor
	(b) FSAR	3A Modified/partial	UIUC MMR is non-power research reactor
	(b)(1) to (2)	3 Applicable as is	
	(b)(3)	3 Applicable as is	
	(b)(4) Final analysis per (a)(4), including 50.46	3A Modified/partial	MMR is NPUF HTGR; 50.46 N/A because has entry condition for power LWRs (see 50.46)
	(b)(5)	3 Applicable as is	
	(b)(6) to (6)(vi)	3 Applicable as is	
	(b)(6)(vii) OLA at multiunit sites	1 N/A	UIUC site is single reactor
	(b)(7) and (8)	3 Applicable as is	
	(b)(9) Protection against pressurized thermal shock per 50.61 & 50.61a	1 N/A	MMR is HTGR - 50.61 & 50.61a N/A (see 50.61 & 50.61a)
	(b)(10) Stationary power reactor OLA comply with App S	2 N/A to NPUF	UIUC MMR is NPUF
	(b)(11) Stationary power reactor OLA provide info per 50.34(a)(1)(ii)	2 N/A to NPUF	UIUC MMR is NPUF
	(b)(12) Power reactor applicants submit 50.150(b) info	2 N/A to NPUF	UIUC MMR is NPUF
	(c) Physical Security Plan - OLA subject to §§ 73.55 or 73.50 and 73.60	2 N/A to NPUF	Differs from 1537: 73.50 & 73.60 do not apply (see 73.50, 73.55 & 73.60)
	(d) Safeguards contingency plan - OLA subject to §§ 73.55 or 73.50 and 73.60	2 N/A to NPUF	Differs from 1537: 73.50 & 73.60 do not apply (see 73.50, 73.55 & 73.60)
	(e) Protection against unauthorized disclosure	3 Applicable as is	

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	(f) Additional TMI-related requirements	1 N/A	MMR is NPUF HTGR; entry condition in 50.34(f) limit applicability to LWR applicants. N/A per 1537 App. A
	(g) Combustible gas control - CPA after 2003 provide analyses and description of equipment required by 50.44	3 <i>Applicable as is</i>	UIUC MMR is NPUF HTGR. Applicable to information, equipment and systems required by 50.44.
	(h)(i) Conformance with SRP - light water OLA after 1982 use SRP revision in effect 6 mo. prior to docketing	1 N/A	UIUC MMR is a research NPUF; apply 1537 SRP revision in effect 6 mo. prior to docketing
	(h)(ii) Conformance with SRP - light water CPA after 1982 use SRP revision in effect 6 mo. prior to docketing	1 N/A	UIUC MMR is a research NPUF; apply 1537 SRP revision in effect 6 mo. prior to docketing
	(i) Mitigation of beyond-design-basis events - power reactors apply 50.155	2 N/A to NPUF	UIUC MMR is a research NPUF HTGR
	50.34a Design objectives for equipment to control releases of radioactive material in effluents— nuclear power reactors.	2 N/A to NPUF	UIUC MMR is research NPUF
	50.35 Issuance of construction permits.	3C Administrative	
	50.36 Technical specifications, except	3 <i>Applicable as is</i>	Will apply to OL
	(a)(2) Applicants under Part 52	1 N/A	UIUC MMR is under Part 50.
	(c)(1)(i)(A) and (ii)(A) Safety limits and settings	3 <i>Applicable as is</i>	104 license under 50.21(c): LER retention for 3 yr.
	(c)(1)(i)(B) and (ii)(B) Fuel reprocessing plants	1 N/A	UIUC MMR is NPUF HTGR, not fuel reprocessing plant
	(c)(2)(ii)(A) Reactor coolant pressure boundary	3B Meet intent	UIUC MMR is HTGR. Per RG 1.232, <i>reactor coolant pressure boundary</i> is replaced by <i>reactor helium pressure boundary</i> in MHTGR-DC 14 and 15. Also, Criteria 2 and 3 have different relevance regarding functional containment. Applicable per 1537 App. A.
	(c)(2)(iii)	1 N/A	Differs from 1537: licenses prior to 1995
	(c)(6) Decommissioning - power reactors & NPUF not authorized to operate	1 N/A	Differs from 1537: UIUC MMR will be licensed to operate
	(d) Tech Specs - OL or CP prior to 1969	1 N/A	Differs from 1537: limited to licenses prior to 1969
	50.36a Technical specifications on effluents from nuclear power reactors.	2 N/A to NPUF	UIUC MMR is NPUF
	50.36b Environmental conditions.	3 <i>Applicable as is</i>	
	50.37 Agreement limiting access to Classified Information.	3C Administrative	
	50.38 Ineligibility of certain applicants.	3C Administrative	

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	50.39 Public inspection of applications.	3C Administrative	
	50.40 Common standards.	3C Administrative	
	50.41 Additional standards for class 104 licenses, except	3C Administrative	
	(a) Medical therapy use	1 N/A	Differs from 1537: UIUC MMR is research reactor, but no medical use
	50.42 Additional standard for class 103 licenses and certifications for commercial power	2 N/A to NPUF	UIUC MMR is Class 104(c) research reactor (see 50.21)
	50.43 Additional standards and provisions affecting class 103 licenses and certifications for commercial power.	2 N/A to NPUF	UIUC MMR is Class 104(c) research reactor (see 50.21)
	50.44 (a-c) Combustible gas control for nuclear power reactors.	2 N/A to NPUF	Applies to currently licensed power reactors and future water-cooled and non-water-cooled power reactor designs. UIUC MMR is a NPUF HTGR. Not listed in NUREG-1537, App. A.
	50.44 (d) Requirements for future non-water-cooled reactor applicants and licensees and certain water-cooled reactor applicants and licensees.	3 Applicable as is	(d) limited to future non-LWRs and certain LWRs. Although the USNC MMR design prevents excessive generation of combustible gases due to the absence of a metal fuel cladding and use of a non-combustible, inert gas for the reactor coolant, as is stated in 50.44 (d), "Applications subject to this paragraph must include; (1) Information addressing whether accidents involving combustible gases are technically relevant for their design, ..." This analysis for DBA and significant BDBA to be provided in the CPA PSAR with consideration to the extent and effect of combustible gases generated. FR 54128 Vol. 68, No. 176 discusses regulatory challenges with rulemaking for designs that are unknown at the time of this final rulemaking.
	50.45 Standards for construction permits, operating licenses, and combined licenses, except	3 Applicable as is	
	(b) COL holder	1 N/A	UIUC MMR licensing via Part 50. Applicable per 1537 App. A.
	50.46 Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors.	2 N/A to NPUF	UIUC is NPUF HTGR; 50.46; entry condition in title limiting to light-water power reactors. N/A per 1537 App. A.
	50.46a Acceptance criteria for reactor coolant system venting systems, for each nuclear power reactor	1 N/A	UIUC is NPUF HTGR; entry condition in first paragraph limiting to power reactors. N/A per 1537 App. A. MMR primary heat transfer medium is helium, which is non-condensable.

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	50.47 Emergency plans.	2 N/A to NPUF	UIUC MMR is NPUF to be licensed under Part 50. 50.47(a)(1)(i) and (b) have entry conditions for power reactors, (c) and (d) cross-reference (a) and (b), and (e) is for Part 52 COL holders. 50.54(q)(1) to (4) & (6) refers power reactor licensees to 50.47(b). N/A per 1537 App. A. RIS 2005-02, Rev 1 [ML100340545] states "Section 10 CFR 50.54(q) and Appendix E to Part 50 establish requirements related to emergency plans for research and test reactors." 1537 Section 12.3 Emergency Planning does not reference 50.47 but instead refers to RG 2.6 and NUEG-0849, which will be the basis for UIUC MMR emergency planning.
	50.48 Fire protection, except for	3 Applicable as is	UIUC MMR is NPUF HTGR. N/A per 1537 App. A.
	(b) through end	2 N/A to NPUF	Entry condition in (b) limits to power plants licensed to operate before 1979, and (c) implements NFPA 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants."
	50.49 Environmental qualification of electric equipment important to safety for nuclear power plants.	2 N/A to NPUF	UIUC MMR is NPUF; entry condition in title limiting to power reactors. N/A per 1537 App A.
	50.50 Issuance of licenses and construction permits.	3C Administrative	No requirements
	50.51 Continuation of license.	3C Administrative	Applies after OL issued
	50.52 Combining licenses.	3C Administrative	
	50.53 Jurisdictional limitations.	3C Administrative	
	50.54 Conditions of licenses, except	3 Applicable as is	UIUC MMR is research reactor to be licensed per Part 52 -50.54 limits to power reactors and Part 52 -50.54(a)(1) limits to licensees subject to 10 CFR 50 App. B, which is N/A to research reactors -Multiple paragraphs limit to licenses in (a)(1): (a)(2) & (3) for power -Paragraphs of this section, except (r) & (gg) and applicable requirements of 50.55a are conditions in every nuclear power reactor operating license. (r) is Reserved; (gg) imposes emergency planning requirements.

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	(a), (m)(2) & (3), (o), (s)(2), (t), (w), (z), (bb), and (ff) to (jj)	2 N/A to NPUF	1537, Part 1, App. A includes all except (a), (m)(2) & (3), (o), (s)(2), (t), (w), (z), (bb), and (ff) to (jj). Determination is made based on 1537
	50.55 Conditions of construction permits, early site permits, combined licenses, and manufacturing licenses, except	3 Applicable as is	
	(e)(3)(iii)(C)	3B Meet intent	UIUC MMR is NPUF not subject to App. B. Breakdowns in QA program will be reported IAW approved program.
	(f) to (h)	2 N/A to NPUF	UIUC MMR is NPUF with CPA submittal after 1983
	50.55a(a) Codes and standards, except	3 Applicable as is	UIUC MMR is NPUF HTGR. Lists codes and standards approved for incorporation by reference, most of which apply to LWRs, but are not mandatory
	(a)(2) and (b)(2)(iii)	1 N/A	UIUC MMR is NPUF HTGR
	(b) to (g) for boiling or pressurized water-cooled reactors	1 N/A	Differs from 1537; UIUC MMR is NPUF HTGR
	(h) for nuclear power plant	2 N/A to NPUF	UIUC MMR is NPUF
	(z) Alternatives to codes and standards requirements in 50.55a(b) to (h)	3 Applicable as is	UIUC MMR is NPUF HTGR; (b) to (h) do not apply
	50.57 Issuance of operating license.	3C Administrative	
	50.58 Hearings and report of the Advisory Committee on Reactor Safeguards.	2 N/A to NPUF	(a) requires ACRS review for test reactors
	50.59 Changes, tests and experiments.	3 Applicable as is	See RG 2.8 for further guidance
	50.60 Acceptance criteria for fracture prevention measures for lightwater nuclear power reactors for normal operation.	1 N/A	UIUC MMR is NPUF HTGR; entry condition limits to lightwater power reactors. N/A per 1537 Appendix A.
	50.61 Fracture toughness requirements for protection against pressurized thermal shock events.	1 N/A	UIUC MR is NPUF HTGR: a(a)(2) limits to PWRs; HTGR not subject to pressurize thermal shock transients
	50.61a Alternate fracture toughness requirements for protection against pressurized thermal shock events.	1 N/A	Same as 50.61
	50.62 Requirements for reduction of risk from anticipated transients without scram (ATWS) events for light-water-cooled nuclear power plants.	1 N/A	§ (a) states applicability is LWRs.
	50.63 Loss of all alternating current power.	1 N/A	§ (a) states applicability is LWRs. MMR does not have safety-related ac power.
	50.64 Limitations on the use of highly enriched uranium (HEU) in domestic non-power reactors.	3C Administrative	UIUC MMR uses HALEU

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	50.65 Maintenance Rule - Requirements for monitoring the effectiveness of maintenance at nuclear power plants.	2 N/A to NPUF	UIUC MMR is NPUF; entry condition in title limits to nuclear power plants. N/A per 1537 Appendix A.
	50.66 Requirements for thermal annealing of the reactor pressure vessel, for light water reactors.	1 N/A	UIUC MMR is NPUF HTGR
	50.67 Accident source term.	1 N/A	Applicable to pre-1997 licenses. UIUC MMR-specific source term will be justified.
	50.68 Criticality accident requirements, for power reactors	2 N/A to NPUF	UIUC MMR is NPUF; entry condition in 50.68(a) limits to power reactor operating license holders. Not listed in NUREG-1537 App. A.
	(b)(7) Maximum enrichment 5%.	2 N/A to NPUF	UIUC MMR is NPUF using HALEU fuel; entry condition in 50.68(a) limits to power reactor operating license holders. However, 70.24 applies to all reactor licensees including NPUF and imposes criticality accident requirements unless 50.68(b) is met. An exemption request may be submitted, as discussed in 70.24 and TR Section 6.1.1.
	50.69 Risk-informed categorization and treatment of structures, systems and components for nuclear power reactors.	2 N/A to NPUF	UIUC MMR is a NPUF and does not use a risk-informed approach.
	50.70 Inspections, except	3 Applicable as is	
	(b)(2) & (b)(4)	2 N/A to NPUF	UIUC MMR is single unit NPUF
	50.71 Maintenance of records, making of reports, except	3C Administrative	Exceptions for 50.22(c) licenses and items applicable to only nuclear power reactors and Part 52 licensees
	(b) and (e) to (h)	2 N/A to NPUF	UIUC MMR is NPUF, N/A per 1537 App. A
	50.72 Immediate notification requirements for operating nuclear power reactors.	2 N/A to NPUF	UIUC MMR is NPUF, N/A per 1537 App. A
	50.73 License event report system.	2 N/A to NPUF	UIUC MMR is NPUF, N/A per 1537 App. A
	50.74 Notification of change in operator or senior operator status.	3 Applicable as is	
	50.75 Reporting and recordkeeping for decommissioning planning, except	3 Applicable as is	
	(b), (c), (e)(1)(iv), (e)(3), (f)(1) to (3)	2 N/A to NPUF	UIUC MMR is NPUF, N/A per 1537 App. A
	50.76. Licensee's change of status; financial qualifications.	2 N/A to NPUF	UIUC MMR is NPUF, N/A per 1537 App. A, and UIUC is not an electric utility.
	50.78 Facility information and verification.	3C Administrative	

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	50.80 Transfer of licenses.	3 Applicable as is	
	50.81 Creditor regulations.	3C Administrative	
	50.82 Termination of license, except	3C Administrative	
	(a) For power reactor licensees	2 N/A to NPUF	UIUC MMR is NPUF, N/A per 1537 App. A
	50.83 Release of part of a power reactor facility or site for unrestricted use.	2 N/A to NPUF	UIUC MMR is NPUF, N/A per 1537 App. A
	50.90 Application for amendment of license, construction permit, or early site permit.	3C Administrative	
	50.91 Notice for public comment; State consultation.	3C Administrative	Introduction states applies to test reactors.
	50.92 Issuance of amendment.	3C Administrative	
	50.100 Revocation, suspension, modification of licenses, permits, and approvals for cause.	3C Administrative	
	50.101 Retaking possession of special nuclear material.	3C Administrative	
	50.102 Commission order for operation after revocation.	3C Administrative	
	50.103 Suspension and operation in war or national emergency.	3 Applicable as is	
	50.109 Backfitting.	3D NRC, not applicant	Pertains to NRC, not to applicants/licensees.
	50.110 Violations.	3C Administrative	
	50.111 Criminal penalties.	3C Administrative	
	50.120 Training and qualification of nuclear power plant personnel.	3B Meet intent	UIUC MMR is NPUF HTGR; entry condition in title limiting to power plants. N/A per 1537 App. A.
	50.150 Aircraft impact assessment.	2 N/A to NPUF	UIUC MMR is NPUF.
	50.155 Mitigation of beyond-design-basis events.	2 N/A to NPUF	UIUC MMR is NPUF.
	Appendix A to Part 50—General Design Criteria for Nuclear Power Plants	1 N/A	RG 1.232 is used instead, per RG no exemption required
	Appendix B to Part 50—Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants	2 N/A to NPUF	UIUC MMR is RTR
	Appendix C to Part 50—A Guide for the Financial Data and Related Information Required To Establish Financial Qualifications for Construction Permits and Combined Licenses	3C Administrative	First paragraph includes test reactors in scope.

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	Appendix E to Part 50—Emergency Planning and Preparedness for Production and Utilization Facilities, except	3A Modified/partial	UIUC MMR is HTGR research reactor with functional containment: - I.3 states "Consequently, the size of Emergency Planning Zones (EPZs) for facilities other than power reactors and the degree to which compliance with the requirements of this section and sections II, III, IV, and V of this appendix as necessary will be determined on a case-by-case basis. ² " and footnote 2 reads " ² Regulatory Guide 2.6 will be used as guidance for the acceptability of research and test reactor emergency response plans. See also 85 FR 28436, "Emergency Preparedness for Small Modular Reactors and Other New Technologies." - UIUC MMR is NPUF. 1537 App. A states subsections I to V are applicable but does not distinguish lower level applicability.
	Appendix F to Part 50—Policy Relating to the Siting of Fuel Reprocessing Plants and Related Waste Management Facilities	1 N/A	UIUC MMR is NPUF.
	Appendix G to Part 50—Fracture Toughness Requirements	1 N/A	UIUC MMR is NPUF HTGR, N/A per 1537 App. A.
	Appendix H to Part 50—Reactor Vessel Material Surveillance Program Requirements	1 N/A	UIUC MMR is NPUF, N/A per 1537 App. A.
	Appendix I to Part 50—Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low as is Reasonably Achievable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents	1 N/A	UIUC MMR is NPUF, N/A per 1537 App. A.
	Appendix J to Part 50—Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors	1 N/A	UIUC MMR is HTGR w/functional containment; see RG 1.232
	Appendix K to Part 50—ECCS Evaluation Models	1 N/A	UIUC MMR is NPUF HTGR, no ECCS 50.46 and App. K for power reactors, N/A per 1537 App. A
	Appendix L to Part 50 [Reserved]	1 N/A	Reserved
	Appendix M to Part 50 [Reserved]	1 N/A	Reserved
	Appendix N to Part 50—Standardization of Nuclear Power Plant Designs: Permits To Construct and Licenses To Operate Nuclear Power Reactors of Identical Design at Multiple Sites	3 Applicable as is	

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	Appendix O to Part 50 [Reserved]	1 N/A	Reserved
	Appendix P to Part 50 [Reserved]	1 N/A	Reserved
	Appendix Q to Part 50—Pre-application Early Review of Site Suitability Issues	1 N/A	UIUC MMR is research reactor: 3rd paragraph of Introduction states scope is for power reactors
	Appendix R to Part 50—Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979	1 N/A	New reactor
	Appendix S to Part 50—Earthquake Engineering Criteria for Nuclear Power Plants	2 N/A to NPUF	UIUC MMR is NPUF: Applicable to power reactors only
51	Environmental protection regulations for domestic licensing and related regulatory functions, except:	3A Modified/partial	Exceptions noted below
	51.1, 51.2, 51.3, 51.4, 51.5, 51.6, 51.10, 51.12 to 17, 51.20 to 22, 51.26 to 30, 51.32 to 35, 51.40, 51.41, 51.45, 51.49, 51.50, 51.53, 51.68, 51.70 to 77, 51.90 to 95, 51.100 to 106, 51.116 to 125, Appendix A	3C Administrative	General environmental info and process.
	51.23 Environmental impacts of continued storage of spent nuclear fuel beyond licensed life for operation of a reactor.	3 Applicable as is	No ISFSI planned; disposition of irradiated MMR fuel removed from the reactor will be under DOE Lease and Takeback Program.
	51.31 Determinations based on environmental assessment	2 N/A to NPUF	UIUC MMR is NPUF.
	51.51 Environmental fuel cycle data	2 N/A to NPUF	UIUC MMR is NPUF.
	51.52 Environmental effects of transport of fuel & waste	2 N/A to NPUF	Applicable to LWRs
	51.54 Environmental Report - Manufacturing License	1 N/A	Applicable to manufacturing license, not Part 50 CP or OL
	51.55 Environmental Report - Standard Design Certification	1 N/A	Applicable to Part 52 DC, not Part 50 CP or OL
	51.60 Environmental Report - Materials Licenses	1 N/A	Applicable to Material Licenses not associated with reactor license
	51.61 Environmental Report – ISFSI or monitored retrievable storage installation license	1 N/A	No ISFSI planned; disposition of irradiated MMR fuel removed from the reactor will be under DOE Lease and Takeback Program.
	51.62 Environmental Report - Land Disposal of Radioactive Waste Licensed Under 10 CFR Part 61	1 N/A	UIUC MMR is NPUF HTGR.
	51.66 Environmental Report - Distribution	1 N/A	Applicable to Material Licenses not associated with reactor license
	51.67 Environmental information concerning geologic repositories	1 N/A	UIUC MMR is NPUF HTGR.
	51.80 & 51.81 Draft EIS - Materials Licenses	1 N/A	Applicable to Material Licenses without reactor license.
	51.85 & 51.86 Drafts EISs - Rulemaking	3D NRC, not applicant	

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	51.88 - Draft EISs - Proposals for Legislation	3D NRC, not applicant	
	51.97 Final EISs - Materials Licenses	1 N/A	No ISFSI planned; MMR core will be removed after end of life under DOE Lease and Takeback Program
	51.105a Public Hearings, Manufacturing Licenses	1 N/A	UIUC MMR is using Part 50 pathway.
	51.107 Public Hearings, combined licenses and limited work authorizations	3A Modified/partial	UIUC MMR is NPUF using Part 50 pathway
	51.108 Public Hearings, ITAAC	1 N/A	UIUC MMR is using Part 50 pathway.
	51.109 Public Hearings for geologic repository	1 N/A	UIUC MMR is NPUF HTGR.
	51 Appendix B	2 N/A to NPUF	UIUC MMR is NPUF being licensed for first time.
52	Licenses, certifications, and approvals for nuclear power plants	1 N/A	UIUC MMR is NPUF HTGR per 50.21(c) licensed per Part 50
54	Requirements for renewal of operating licenses for nuclear power plants	2 N/A to NPUF	UIUC MMR is NPUF HTGR.
55	Operators' licenses except	3 Applicable as is	N/A per 1537 App. A.
	55.5(b)(2)	2 N/A to NPUF	UIUC MMR is NPUF; entry condition in 55.5(b)(2) limiting to power reactors.
60	Disposal of high-level radioactive wastes in geologic repositories	1 N/A	UIUC MMR is NPUF HTGR.
61	Licensing requirements for land disposal of radioactive waste	1 N/A	UIUC MMR is NPUF HTGR.
62	Criteria and procedures for emergency access to non-federal and regional low-level waste disposal facilities	1 N/A	UIUC MMR is NPUF HTGR.
63	Disposal of high-level radioactive wastes in a geologic repository at Yucca Mountain, Nevada	1 N/A	UIUC MMR is NPUF HTGR.
70	Domestic licensing of special nuclear material, except	3 Applicable as is	Per 1537 App. A, SNM license normally part of Part 50 application. 70.24(c) exempts reactors under part 50 from 70.24(b)
	70.11 DOE and NRC contractors; 70.12 Carriers; 70.13 DoD; 70.14 Foreign military aircraft	1 N/A	UIUC is US public education institution; differs from 1537 App. A
	70.24 Criticality Accident Requirements	3 Applicable as is	UIUC MMR is NPUF. Applicable per 1537 App. A.

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	70.1(b) to (e), 70.13, 70.20b, 70.21(a)(1) and (g), 70.22(b), 70.22(f), 70.22(h), 70.22(k), 70.22(m), 70.23(a)(8) and (10) to (12), 70.23a, 70.31(e), 70.32(k), 70.39, 70.55(c)(1) & (2), 70.59, 70.64.	2 N/A to NPUF	UIUC MMR is a research reactor, N/A per 1537 App. A.
71	Packaging and transportation of radioactive material	2 N/A to NPUF	71.4 defines spent nuclear fuel as being used in a power reactor. Other radioactive material requirements apply.
72	Licensing requirements for the independent storage of spent nuclear fuel and high-level radioactive waste, and reactor-related greater than Class C waste	2 N/A to NPUF	UIUC MMR is NPUF.
73	Physical protection of plants and materials, except:	3 Applicable as is	
73	73.6 Exemptions 73.20, 73.25, 73.26, 73.27, 73.45, 73.46, 73.70, & 73.72 not applicable: (a) if uranium enrichment <20% (e) SNM at non-power reactors	2 N/A to NPUF	UIUC MMR uses HALEU (enrichment >5% to <20%) and is a NPUF, meeting 73.6 on two criteria. Note that 73.21 defines >10 kg of U-235 enriched between 10 and 20% as of moderate strategic significance.
	73.20, 73.25, 73.26, 73.27, 73.45, 73.46, 73.70, and 73.72.	2 N/A to NPUF	Exempt per 73.6
	73.21(a)(i) Protection of Safeguards Information for power reactors	2 N/A to NPUF	UIUC MMR is NPUF.
	73.21(a)(1)(ii) Protection of Safeguards Information for research and test reactors	3C Administrative	Applies to NPUF having SNM of moderate or low strategic significance.
	73.23 Safeguards Information - Modified Handling rules	3C Administrative	UIUC MMR meets 72.21(a)(1)(ii)
	Subpart D—Special Nuclear Material of Moderate Strategic Significance	3 Applicable as is	UIUC MMR will use HALEU enriched < 20%.
	73.45(a) to (f), 73.46(c), (e), and (f)	2 N/A to NPUF	UIUC MMR is NPUF exempted by 73.6.
	73.50 Requirements for physical protection of licensed activities	1 N/A	UIUC MMR will be licensed under Part 50
	73.51 Physical protection of stored spent nuclear fuel and high-level radioactive waste	2 N/A to NPUF	Does not apply to NPUF as Part 72 does not apply to NPUFs
	73.54, 73.55, 73.77	2 N/A to NPUF	UIUC MMR is NPUF.
	73.56, 73.58	2 N/A to NPUF	UIUC MMR is NPUF.
	73.60 Additional requirements for physical protection at nonpower reactors possessing ²³⁵ U enriched to ≥ 20%	1 N/A	UIUC MMR will use HALEU enriched < 20%.

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
	73.67 Fixed site and in-transit requirements for physical protection of SNM of moderate or low strategic significance	4 Request exemption	UIUC MMR has SNM of moderate strategic significance (>10 kg of HALEU), but all contained in prefabricated TRISO particles encased in an FCM matrix pellet loaded into graphite blocks. The fuel blocks are unattractive targets and remain within the reactor vessel throughout the entire operating life or during refueling. See TR Section 6.1.1.
74	Material control and accounting of special nuclear material	4 Request exemption	See TR Section 6.1.1.
	74.1, 74.2, 74.4 to 8, 74.11, 74.13, 74.15, 74.17, 74.19, 74.81 to 84	2 N/A to NPUF	UIUC MMR is NPUF.
	Subpart C—SNM of Low Strategic Significance - 74.51 to 59	2 N/A to NPUF	UIUC MMR SNM is enriched<20%; it is of moderate significance.
	74.41, 74.43, 74.45	1 N/A	UIUC MMR is NPUF.
	74.31 Nuclear MC&A for SNM of low strategic significance.	3B Meet intent	
	74.33 Nuclear MC&A for uranium enrichment facilities.	1 N/A	UIUC MMR is NPUF.
	Subpart D—Special Nuclear Material of Moderate Strategic Significance	3 Applicable as is	
	Subpart E - Formula quantities of SNM	2 N/A to NPUF	UIUC MMR is NPUF to be licensed to Part 50
75	Safeguards on nuclear material—implementation of safeguards agreements between the United States and the International Atomic Energy Agency	3 Applicable as is	
76	Certification of gaseous diffusion plants	1 N/A	UIUC MMR is NPUF, not an enrichment plant.
81	Standard specifications for the granting of patent licenses	3D NRC, not applicant	
95	Facility security clearance and safeguarding of national security information and restricted data	3C Administrative	
100	Reactor site criteria	2 N/A to NPUF	UIUC MMR is NPUF research reactor; entry condition in 100.1(a) limits to stationary power and test reactors. N/A per 1537 App. A.
110	Export and import of nuclear equipment and material	3C Administrative	
140	Financial protection requirements and indemnity agreements	3C Administrative	UIUC MMR is research reactor; therefore, 140.11(3) applies.
150	Exemptions and continued regulatory authority in Agreement States and in offshore waters under Section 274	1 N/A	UIUC MMR is NPUF to be licensed per Part 50.
160	Trespassing on Commission property	3D NRC, not applicant	

Part No.	Title 10 Regulation Topic Paragraph hierarchy: Title/Chapter/Part (Subpart)/Section/Paragraph Paragraph levels: (a)(1)(i)(A)(1)(i)	UIUC MMR Regulation Applicability Group	Rationale/Justification/Comment (no entry required for 3, 3C, or 3D responses)
170	Fees for facilities, materials, import and export licenses, and other regulatory services under the Atomic Energy Act of 1954, as amended	3C Administrative	UIUC is a non-profit educational institution, and the UIUC MMR is NPUF: (a)(4) No application fees, license fees, etc.
171	Annual fees for reactor licenses and fuel cycle licenses and materials licenses, including holders of certificates of compliance, registrations, and quality assurance program approvals and government agencies licensed by the NRC	3C Administrative	171.11 Exemptions. (b) An annual fee is not required for (1) A construction permit or license applied for by, or issued to, a nonprofit educational institution for a production or utilization facility, other than a power reactor, ..." UIUC is a non-profit educational institution, and the UIUC MMR NPUF.
	171.1 Annual fees	3C Administrative	
172	Parts 172 through 199 are [RESERVED]	1 N/A	